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EVERYBODY'S HAND-BOOK OF ELECTRICITY

WITH

Glossary of Electrical Terms and Tables for Incandescent Wiring.

ILLUSTRATED.

1. *Electricity and Magnetism; discovery and Early experiments.*
2. *The Dynamo.*
3. *Electric Lamps.*
4. *Electric Motors.*
5. *Electric Railway.*
6. *Electric Welding.*
7. *Measuring Instruments.*
8. *Electric Batteries, Bells, etc.*
9. *Incandescent Wiring Tables.*
10. *Appendix—Some miscellaneous Electrical Inventions.*

By EDWARD TREVERT.

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LYNN, MASS.:
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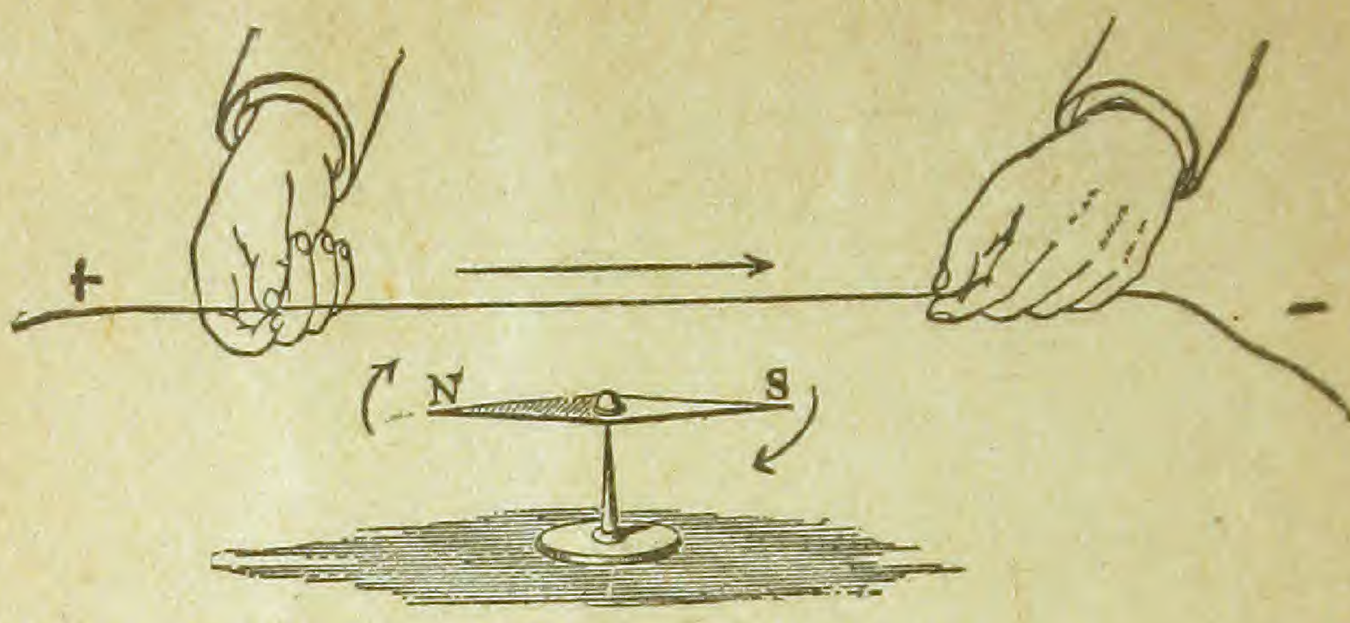

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PREFACE.

In presenting this little book to the public I simply invite the reader to follow me in a brief outline of the rapid advancement that practical application of electricity to motive power, etc., has taken in the last few years and to accept the facts which I have obtained from some of the best electricians in the country. Being aware of the chief drawbacks in most standard works on the subject, I have tried to avoid technicality and to give a brief and simple description of the subject in a manner for the ready comprehension of everybody.

The following works have been consulted in the preparation of this volume: "Dynamo-Electric Machinery" and "Elementary Lessons in Electricity and Magnetism," by Sylvanus P. Thompson; "Electricity in the Service of Man," by R. Wormell, D. Sc., M. A.; "The Electric Motor and its Applications," by Messrs. Martin and Wetzler. I am also indebted to the several standard electrical publications of the day, such as the "Electrical World," "Electrical Review," "Engineering News," "Western Electrician" and the "Electric Age." I wish, also, to make grateful acknowledgements to Mr. Albert L. Rohrer, of the Thomson-Houston. Co, at Lynn, Mass., and the several other electricians of the same and other companies for valuable assistance rendered.

EDWARD TREVERT.

LYNN, MASS., 1889.

PREFACE TO FIFTH EDITION.

In no other field are there so many changes and improvements constantly being made as in the Electrical Field. Hundreds of new patents are being taken out every year and in order for one to be up to the times he must not lose a moment in his studies of this all absorbing science.

Since the first publication of this volume a little over one year and a half ago, twenty-eight thousand copies have been sold—a very flattering success to the author. For these reasons I have thought it advisable to revise the fifth edition hoping that its success may continue.

EDWARD TREVERT.

Lynn, Mass,. Sept. 1, 1891.

PREFACE TO SEVENTH EDITION.

The rapid strides which Electricity is taking and the many changes taking place from day to day in the construction of Electrical Machinery have compelled me to again revise this little book. Such changes have been made as thought best by the author to bring it up to date.

EDWARD TREVERT.

Lynn, Mass., Jan. 1, 1894.

ELECTRICITY AND MAGNETISM.

DISCOVERY AND EARLY EXPERIMENTS.

Geographers in studying a river are not satisfied by simply making an examination of its mouth, noting width, depth and volume of water flowing in a unit of time, etc., but it is best understood by tracing its sources and its tributaries. How much, or rather how little would we know about the great father of waters—the Mississippi—unless we traced it to Lake Itasca, and its main tributaries to their sources in the Alleghany and Rocky Mountains. So in attempting to acquaint ourselves with the principles upon which the practice of electricity to-day is founded, it is desirable to review briefly the *early* knowledge and progress of the science, and to trace the tributaries in the shape of discoveries of this mighty river, if you please, whose current has within the last half century or less, completely revolutionized business methods and well-nigh social life. The continuous progress in the advancement of science shows that no one man or no one generation of men, can be justly credited with all that is connected with any of the great discoveries with which science has enriched the world. They have all had the benefit of the experience and labors of their predecessors and have built upon them.

The first knowledge of electricity came from the fact that when amber was rubbed it attracted light particles;

this is the original experiment and has been handed down from the remotest antiquity. No doubt that a great deal of the romance connected to this substance is due to this fact. The statement is made in early writings that workmen engaged in polishing amber, which was highly prized by the ancients as an ornamental gem, were seized with violent tremors in their arms, an exaggerated account of what might have occurred from rubbing the substance. For several centuries this suggestive experiment was forced to stand alone without any attempt to investigate. Electricity above all other sciences is wholly dependent upon experiment for its development. It is the product of the laboratory and of the scholar, and is not due to the genius of the inventor. Naturally then it had to await the coming of the seventeenth century, or rather the closing of the sixteenth century, when Lord Bacon by his philosophy, and William Gilbert by his work, awakened the time to the fact that experimental research and inductive methods were the true principles of philosophy.

Dr. Gilbert, who was first physician to Queen Elizabeth, can be justly ascribed the creator of electricity by virtue of the large number of experiments he made and the conclusions he arrived at. He found that many substances other than amber possessed the power of attracting light particles when rubbed, such as glass, sulphur, etc. The next two centuries saw great strides in the development of this new science in which the philosophers of that time were all interested. You are all somewhat familiar with the work of Benjamin Franklin, "whose discoveries," according to a celebrated English electrician, "were so extensive and brilliant as to give a form and dignity to the science of electricity

which it had never before possessed, and raised their author to a high rank among the distinguished philosophers of the eighteenth century." To Franklin is due the first and only really useful application to the affairs of every day life of all these years of study and thought; I refer to his invention of means for protecting buildings from damage by lightning.

At the close of the eighteenth century an Italian philosopher saw in the twitching of a frog's legs the opening of a new field in electricity, or we might say modern electricity. The well established story goes that Galvani had been investigating the effect of electricity on the muscles of frogs, and some of these animals were hung on an iron railing by means of copper hooks, and it was noticed that the muscles twitched when there was no electrical disturbance apparent in their vicinity. Galvani, whose experiments hitherto in this line were confined to an electrical machine, was led to believe that the frog itself was the source of the electricity, and that the pieces of iron and copper were only conductors. It is not necessary to add that when Galvani's discovery became known it attracted the attention of students of electricity in all countries.

Volta, a countryman of Galvani, found that two different metals were essential in the production of the new electricity, and he constructed his battery, or pile, which was composed of silver coins and pieces of zinc, with moistened paper between them; with this he found it possible to produce all the effects of electricity which were produced by friction on glass and sulphur. The voltaic pile was, however, improved in a very short time by Volta, and instead of building it up simply with two pieces of metal with moistened paper between, the

metal strips were placed in cups of water in very much the shape we find it to-day. As these experiments of which we have spoken were published to the world, a great many other men began working in the same direction, and before long it was discovered that the electric current would decompose water, and electro chemistry came up for its share of attention. This interested a great many men, to one of whom especially is due a very historical experiment, which I shall speak of later. I refer to Sir Humphrey Davy, who became very much interested in these experiments and who constructed a number of very large batteries. He became so much interested in his brilliant discoveries that he could with great difficulty compose himself, and the mental labor and the excitement he experienced at the time threw him into a typhoid condition which threatened his life — and they were remarkable experiments, and I do not wonder that the man at the time was wrought up to such high pitch because there were so many ideas crowded upon him as to throw him into a sort of nervous prostration. As soon as he recovered from this attack of typhoid fever he constructed his large battery which was composed of something like 2,000 cells, and this historic battery was the source of the first flashes of the electric arc. That was in 1810. If you will allow me I will read a brief description which Davy wrote at the time. He says: "When pieces of charcoal about an inch long and one-sixteenth of an inch in diameter were brought near each other, say one-thirtieth or one-fortieth of an inch, a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness, and by withdrawing the points from each other a constant discharge took place through the heated air in a space

equal at least to four inches, producing a most brilliant ascending *arch* of light, broad and conical in the middle." Of course the light did not last long as the charcoal being soft burned rapidly away and the pieces of charcoal were simply fed towards each other by hand. But very soon this was improved upon by Foucault and by others, who made a lamp which would feed the carbons by clockwork.

You will please note then that the singular discovery of Galvani, and the experiments of Volta, may be regarded as the introductory to the modern applications of electricity, as they made a great stride toward the electric light, the telegraph and the telephone.

Although the names of the discoverers of most of the important inventions and the locality where they were discovered is known, yet no doubt all the world would be very glad to do honor to the discoverer of the magnet and the inventor of the magnetic needle or mariner's compass. But the history of these is unknown. It is said that in the records of the Chinese, some 2,600 years before Christ, that they knew and made use of the magnet (the natural magnet or loadstone), and I believe the fact is noted in their histories that their armies were led across the large plains in the interior by a combination of loadstones which is represented by the figure of a man. They carried him along in a wagon and his extended arm always pointed toward the south, which is opposite to the direction in which we consider the needle as pointing—towards the north. It is also known to have been in use in a similar manner in Japan. The Greeks and Romans knew of the attractive power of the loadstone or the natural magnet, but were entirely ignorant of its polarity. Its attractive power was

known because it is spoken of in the literature of the day, one in particular, where a shepherd is said to have been held to a magnet rock by the iron on the end of his staff. We also know that these loadstones or natural magnets were made use of in the ceremonies of the temples. Many of you are probably familiar with the story of Mahomet's coffin, which is said to have risen from its resting place and "soared in a sanctuary built of magnetic stone." There are many such traditions. One in particular occurs to me, that there was a very large magnetic mountain in the sea over which it was impossible for ships to sail because of the iron bolts and other iron articles on it, so that when a ship passed over this mountain it would pull it to the bottom. Besides this it was supposed that if anyone carried with him a loadstone it would win him the love and friendship of others, or would make him successful in business. And it was also stated that having a loadstone it would be possible for a man to tell whether a bride had accepted him from motives of affection or considerations of a pecuniary nature.

Soon the scientific minds of the day suspected that there must in some way be a very intimate relation between magnetism and electricity, and there were many minds seeking after the missing link. It was left to the son of a Danish apothecary to make the second great discovery in electricity. I refer to Oersted's discovery that a magnetic needle when placed parallel to a conductor carrying an electric current would be deflected from its position to the right or to the left as the case might be. This pointed out an entirely new field, and in a very few days after he made this discovery the laws concerning this phenomenon were put into practical shape

by Ampere, whose name we make use of in one of the electrical units of to-day. It is upon this discovery by Oersted and its explanation by Ampere, that the whole science of electric-dynamics rests. The fact that a current of electricity would affect a magnet was a forerunner of the electric telegraph. The first electro magnet may be considered to have been constructed by Sturgeon, who wound several turns of bare copper wire around a bar of iron, simply insulating the bar and winding the wire upon it, a thing which seems very crude to us to-day. It was soon discovered by another man—I refer to Prof. Henry—that the magnet could be made more powerful by putting more wire on it and insulating the wire by wrapping it with cotton or some other material. He constructed some very large magnets in this manner. Thus we have the discoveries of Galvani and Volta which constitute the first step, then the discovery by Oersted and the theory expounded by Ampere that make up the second great discovery of electricity. This history would be entirely incomplete however, were we to leave out another man, a man for whom I have a great deal of veneration, and upon whose work the whole science of dynamic electricity rests. I refer to Michael Faraday, the distinguished son of an English blacksmith, to whom and to whose work is due all the striking applications of electricity we see in use to-day. Faraday was prepared for his great work by his association with Sir Humphrey Davy in the capacity of an assistant. He was a man who stood beyond all other men of the period, and on him rests a great deal of the success attained in the study of this science. Tyndall says of him that "The intentness of his vision in any direction did not apparently diminish his power of per-

ception in any other direction, and when he attacked a subject expecting result, he had the faculty of keeping his mind alert so that results different from those which he expected should not escape him through preoccupation." He began his work in 1825. Faraday knowing that magnetism was produced by electricity, attempted to produce electricity from magnetism, and in his original experiment he used an iron ring on which was wound two separate coils of wire, to the terminals of one coil he connected a battery, and the terminals of the other coil were connected to a galvanometer, which as I have already explained, will detect the presence of a current of electricity. A coil of wire consisting of a few turns, the ends of the wire connected to the reflecting galvanometer, will also illustrate what is meant by induction. Whenever the bar magnet is moved towards or away from the coil, the spot of light is seen to move to the right or to the left as the case may be, and is only momentary, lasting during the time of movement. Let the magnet be fixed and the coil of wire moved and the same results are obtained.

All that is necessary in producing a current of electricity is that some change is made in the coil of wire or in the magnetic atmosphere in which it is placed. In other words, whenever the number of lines of magnetism or lines of force threaded through a coil of wire is made to vary, then there is produced in the coil a current of electricity. The model of the first dynamo machine that was ever made involves this principle, and the original was invented and manufactured in a single day by Faraday. It consists of a copper disc so mounted that it can be revolved between the poles of a magnet; the axis and edge of the disc constitute the terminals and are connected to the galvanometer; on turning the disc the

spot of light moves across the screen showing the presence of a current of electricity. This then is the parent of all dynamos that are to day producing the electric energy which floods with light all the civilized towns and cities of the world. Some of the earlier forms were constructed by Pixii, Pacinotti and Clarke; Dr. Charles G. Page, a physician of Salem, was among the early workers and designed some very good types. It is said that he constructed his first electrical machine when but ten years old. After these we have the Alliance, Wilde, Ladd, Gramme, Siemens, Brush, Weston, Edison, the large Gordon and Thomson-Houston.—*(From a lecture given by Albert L. Rohrer, of Thomson-Houston Co.)*

The Dynamo Electric Machine.

Until the invention of the dynamo, the electric battery was the only known generator of the electric light, and it required a battery of 40 to 50 Grove cells to produce a strong light that would last but a few hours. The expense and labor of renewing the fluid in these cells every few hours, the large amount of space they would occupy, and the noxious fumes arising from such a battery, made its use impracticable. Bearing these facts in mind, it is easy to see why electric lighting, though known in 1800, was only a laboratory experiment until about 1867.

The dynamo or electric generator consists of a field and an armature.

The field consists of magnets, which are iron cores solidly connected with an iron frame. Upon the magnets are wound layers of insulated wire. These magnets are called electro magnets, as they become magnetic only when there is an electric current passing through their coils.

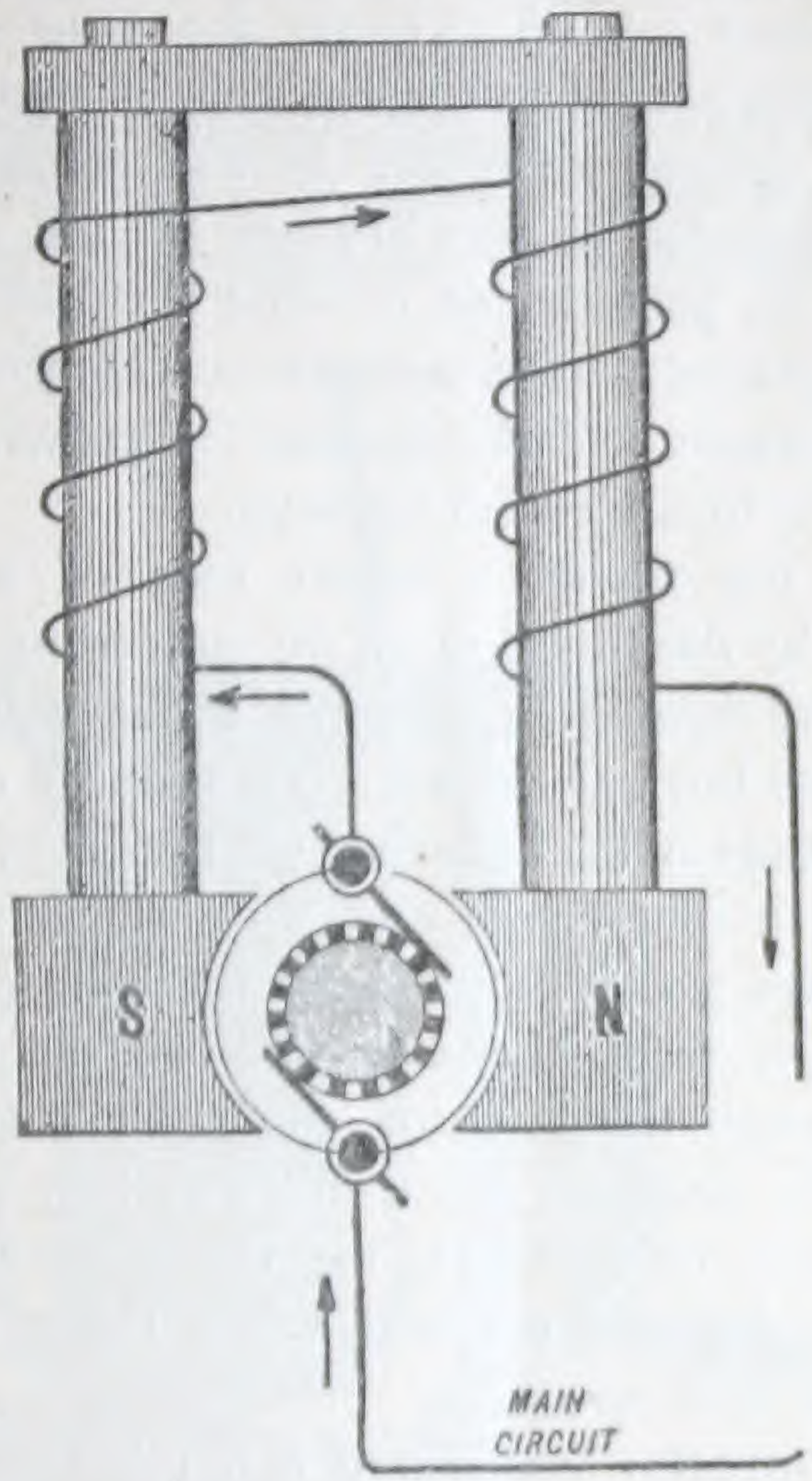
The armature consists of a shaft to which a number of coils of insulated wire are affixed, and rotates between the poles of the magnet. Metal plates or bundles of wire called brushes conduct the current generated in the armature to the circuit.

There are two types of dynamos: the continuous current and the alternating current dynamo.

In the continuous current dynamo the current gen-

erated always flows in the same direction, there being a commutator from which the current is collected by the brushes.

In the alternating current machine the current generated flows at rapid intervals, first in one and then in



the opposite direction. This dynamo having no commutator, a collector of two metal rings is necessary on which the brushes rest. The magnets of this machine must have a continuous current to excite them, and this current is generated by another small, continuous current machine which is called the exciter.

There are three ways of winding dynamos: the series, the shunt and the compound. In the series wound dynamo, the generated current is passed through the field magnet coils which are connected in series with the armature and external circuit.

In the shunt wound dynamo the field magnets are wound with fine wire to receive only a small portion of the whole current generated in the armature. These coils are connected to the brushes of the machine and constitute a by-pass circuit, or what is called a shunt.

The compound wound dynamo is a combination of the series and shunt. This dynamo is growing in favor, especially for incandescent lighting.

To give the reader a better idea of a dynamo, I illustrate it by the diagram on the preceding page.

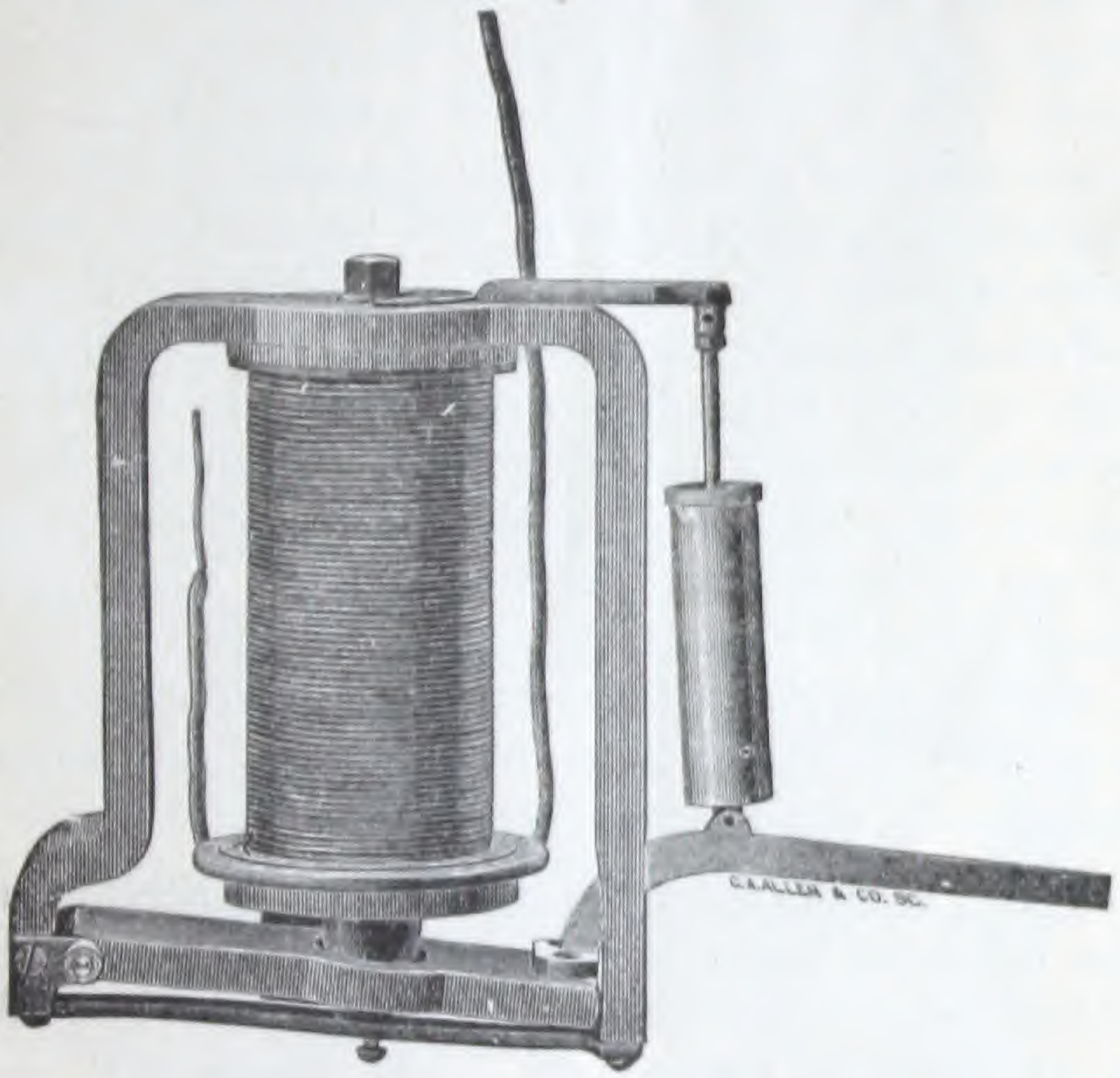
This figure represents a simple series wound dynamo and possesses but one circuit. To simplify the principle, in the illustration the winding of the field magnets is confined to a few turns, and by noticing the direction of the arrows you will see that there is a continuous current taken from the armature by the brushes and carried through the coils of the field magnets to the circuit. To produce a current a certain speed of the armature must be obtained, for the machine will refuse to magnetize its own magnets when there is too much resistance or little speed.

The commutator consists of a number of metal bars fixed radially around the shaft of the machine, each bar being insulated from one another, and each bar obtains its electricity from the coil or coils attached to it. The commutator is employed to change the direction of the current generated.

The regulator is for regulating the flow of the current

to meet the demands of the circuit. Without it there would be no way to regulate varied effects of lighting additional lamps, or of extinguishing them, and there would be a constant danger of overheating and burning out of the armature and field magnets, short circuiting, etc.

The Thomson-Houston Regulator is an electro magnetic regulator; that is, it depends on the electro magnet to adjust itself. The regulation of the current is obtained



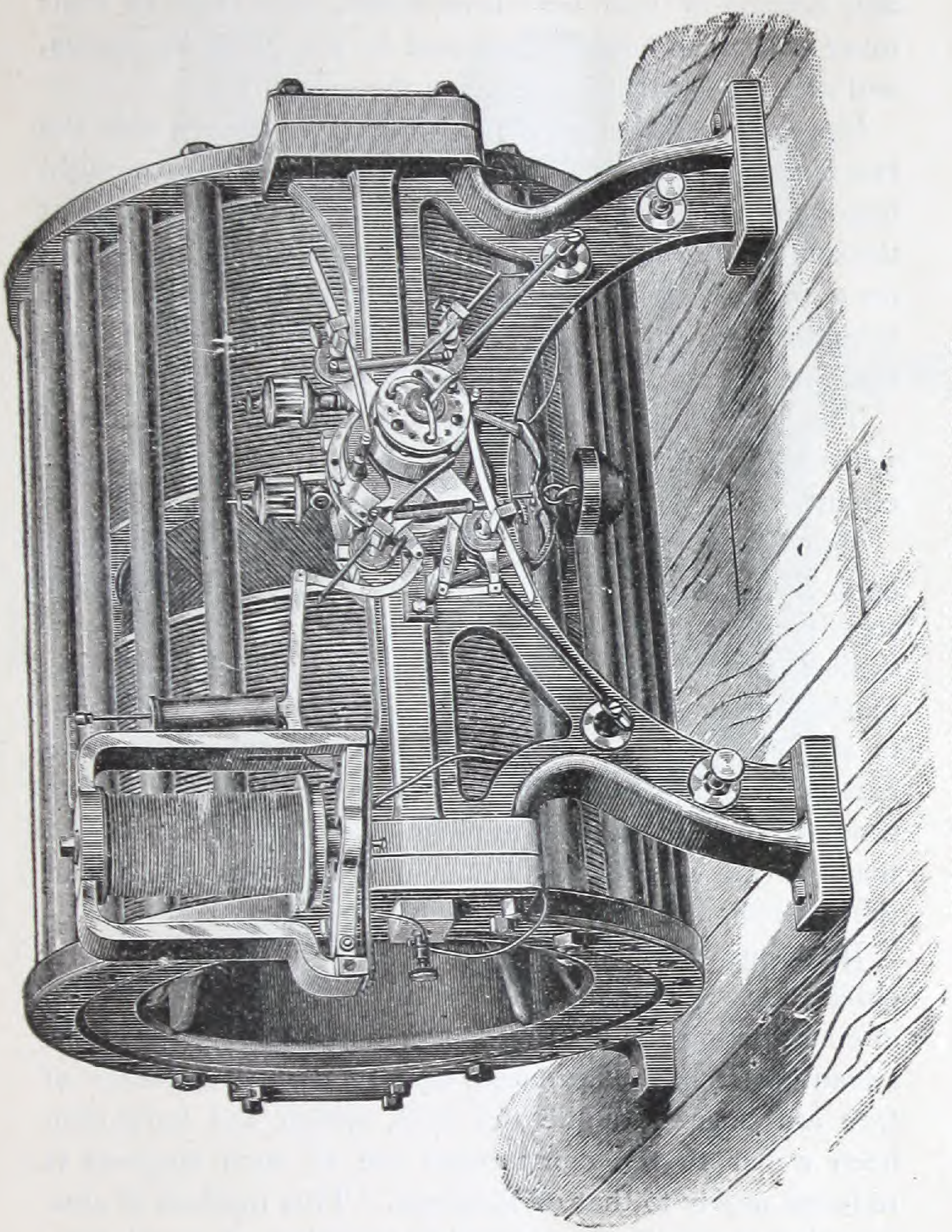
by automatic shifting of the brushes in such a way that they short circuit one of the armature coils for a greater or less period of time, as the occasion may require. This is accomplished by a contrivance shown in the cut above.

When from a reduction of resistance in the lamp circuit by the extinguishing of a lamp, or otherwise, the current feeding the other lamps becomes liable to an abnormal increase; this increase of current is made to flow through the coils of wire surrounding the iron core of the regulator; the core then becomes magnetized causing the yoke to which the brushes are attached to be drawn up towards the regulator magnet. This results in shifting the brushes on the commutator, so that they draw away from the maximum point, decreasing the potential. When more lights are turned on the reverse action takes place. The current governing the regulator is cut in and out by means of a pair of electro magnets, termed the controller magnets, connected with the regulator magnet of the dynamo.

Perhaps it would not be amiss to say here, that a few years ago electricians looked forward to the delivery of 80 to 85 per cent of the engine power operating the dynamo. Now the best dynamos deliver in electrical power over 93 per cent of the steam power transmitted to them.

Now that we have gone over the general principles of a dynamo electric machine, we will look into some of the different systems.

The Thomson-Houston Arc Dynamo, illustrated on the following page, is remarkable for its construction. It was designed by Professors Elihu Thomson and Edwin J. Houston, of Philadelphia. Its armature is nearly spherical and is wound with only three coils. The three coils are wound over the shell of the armature in three sets of windings, each layer being insulated from the shell and its neighbors. When the winding is completed the three ends of the free coils are carried through an opening in the shaft and attached to the three segments



THOMSON-HOUSTON ARC DYNAMO.

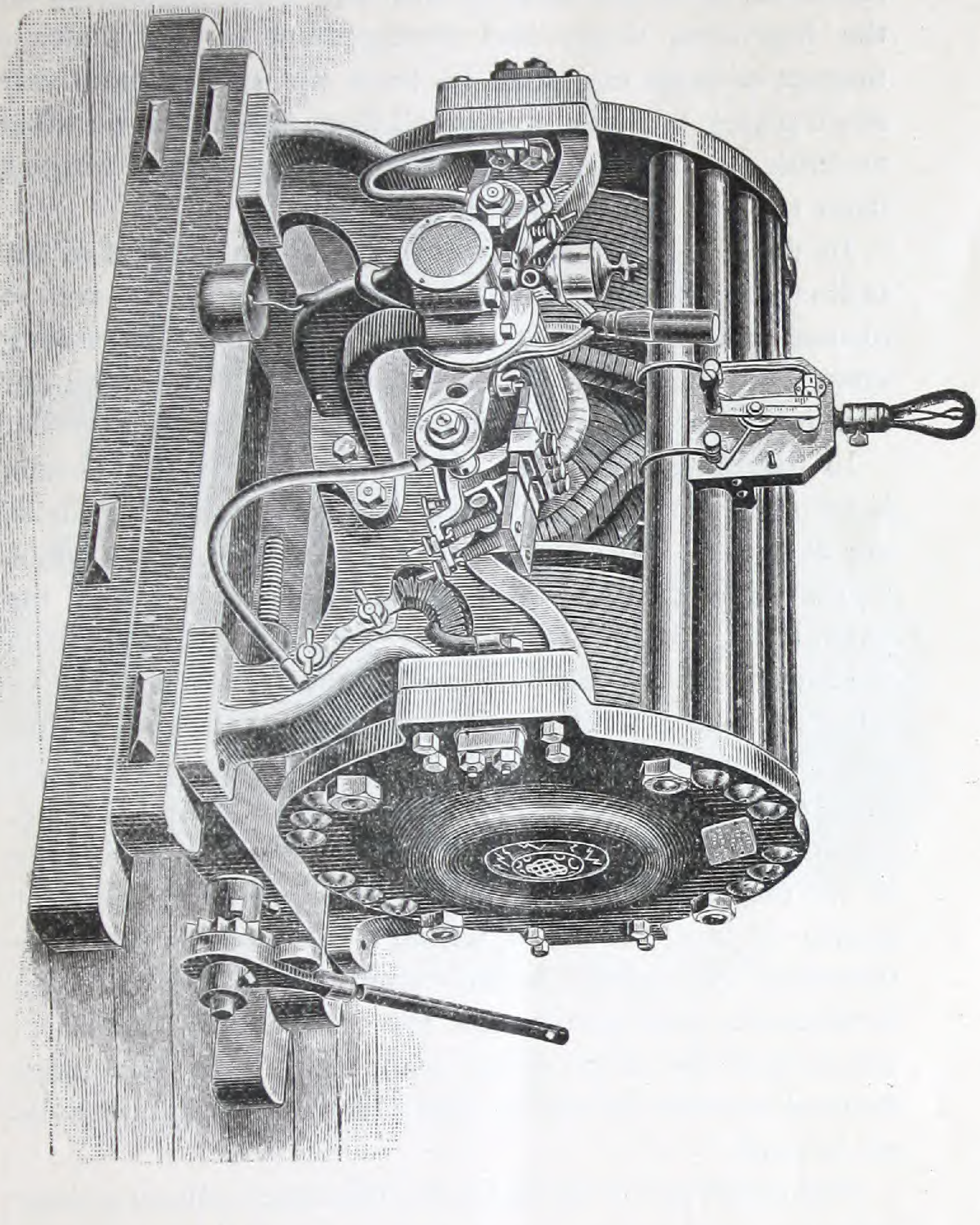
of the cummutator. The field magnets are cup shaped; they consist of two cast iron tubes, furnished at their inner ends with hollow cups cast in one with the tubes, and accurately turned to receive the armature.

Upon these tubes are wound the coils; afterwards the two magnets are united by means of a number of wrought iron bars which constitute the yoke of the magnet and at the same time protect the coils. The magnets are carried on a framework which also supports the bearings for the armature shaft. Another remarkable feature of this machine is that its commutator has only three parts.

The largest machines have an electromotive-force of 3,000 volts, and will maintain 63 arc lights in a single circuit.

The Thomson-Houston (direct-current) Incandescent Dynamo designed by Professor Elihu Thomson for supplying large currents at low potential is outwardly of similar structure to the arc dynamos. But in this machine the spherical armature is wound as a closed-coil in sixteen sections. The field magnets are much more massive and the output of the machine more than five times as great in proportion to its size. It is compound wound; the series coils being nearest to the armature with the shunt coils behind them.

Description of Perret Dynamos and Motors. — The chief distinctive feature of these machines is the method of constructing the field magnet whereby the well-known advantages due to lamination and to the best quality of iron are secured, while the cost, which has heretofore been a bar to the commercial use of such magnets is reduced nearly to that of forgings. This method of construction is peculiarly adapted to machines of small size, and by its use their efficiency is greatly increased, as a



THOMSON-HOUSTON INCANDESCENT DYNAMO.

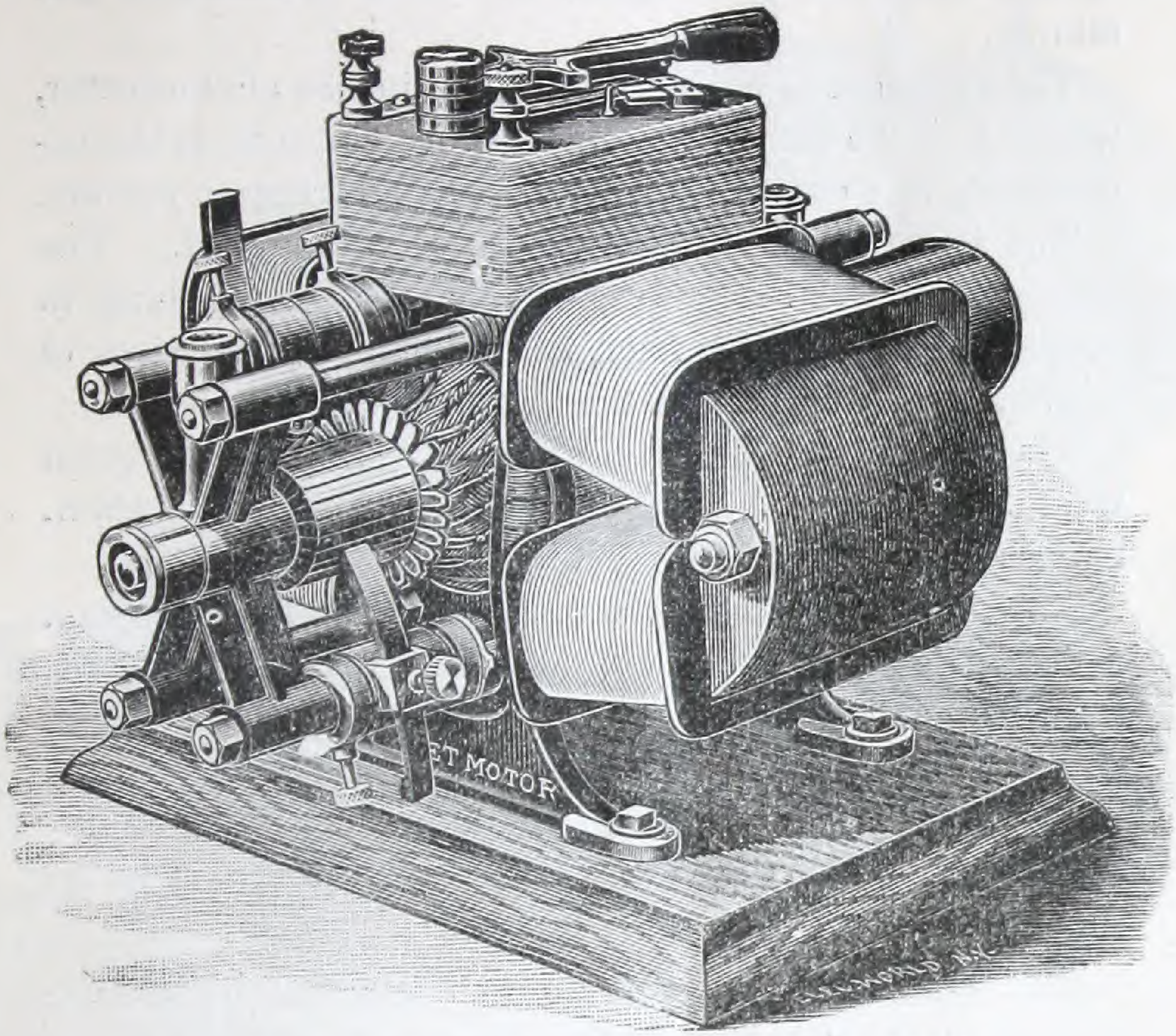
test will show. It may also be used to advantage in machines up to ten-horse power and even higher, as by the ingenious shape and arrangement of the plates a magnet of large size may be built up of comparatively small plates, which are stamped from sheet iron, no other machine work being necessary. Eight sizes, ranging from 1 1-2 to 2 H. P. are now made.

In the 1 1-2, 1-8 and 1-6 H. P. sizes, a magnet of the ordinary U-shape is used in which the plates are so formed and put together that the limbs may be swung apart and clamped to the face plate of a lathe for winding, after which they are swung back and bolted fast.

In machines of 1-4 H. P. and upwards the double horse-shoe shape, with consequent poles, is used. These are shown in the illustration on the following page. Upon removing the two bolts which pass through the yoke, the top half of the magnet may be separated from the lower half. Each half is then attached to a lathe or other suitable machine and wound by revolving it, after which they are put together and the bolts replaced, all these operations being very simple and very rapidly done.

An important feature is the extremely low resistance of the magnetic circuit, which is due partly to superior quality of iron, the use of which is allowed by this construction, and partly to the smallness of the air gap between the pole pieces and the iron of the armature, which is of the drum type, with teeth. In the longitudinal recesses formed by these teeth the armature coils are wound.

This construction increases the efficiency, allows a large reduction in armature speed, and improves the regulation. As showing this, reference is made to the 1-2 H. P. machine (see illustration) which weighs complete with



THE PERRET DYNAMO AND MOTOR.

pulley seventy pounds, and has a commercial efficiency of eighty to eighty-five per cent. As a shunt-wound dynamo it will generate a current of four amperes at 110 volts when run at a speed of 1,800 revolutions per minute.

The armature is wound with 7,000 inches of conductor, which is at the rate of about 64 inches per volt, at the remarkably low peripheral speed of 1,500 feet per minute.

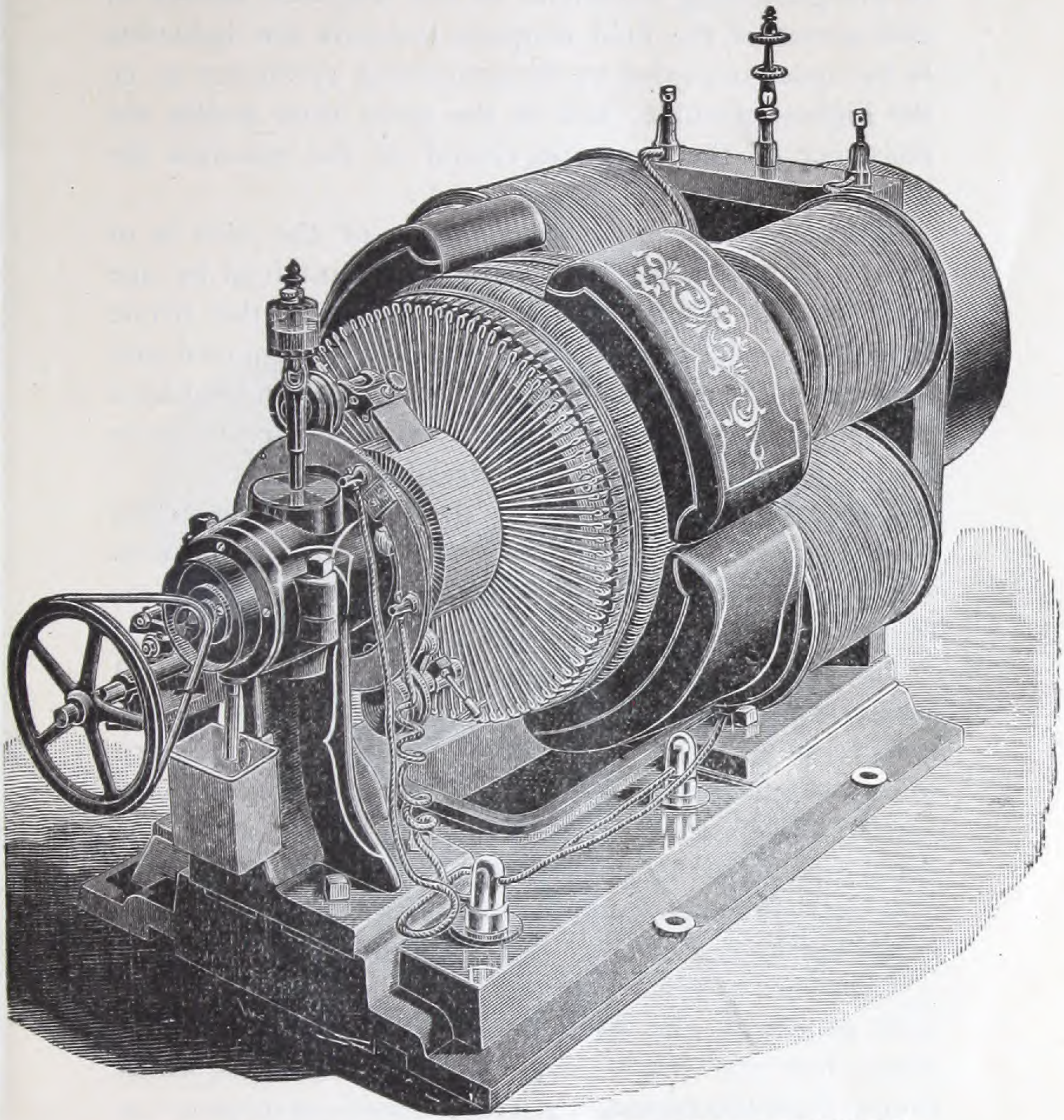
The armature shafts are of high grade steel. The bearings are all accurately fitted and are very long in proportion to their diameter, being in the smaller sizes of hard composition, and in the larger of babbitt metal.

The commutators, which ordinarily are liable to great wear and damage, have received particular attention, being made of a special hard bronze.

The motors are usually shunt-wound, and on constant potential circuits run at practically a constant speed, regardless of changes in load. They are provided with switches for starting and stopping, and in the larger sizes the switches are provided with resistance coils, an arrangement which is much handier than a separate rheostat.

The New Sperry Dynamo is illustrated in the engraving on the following page.

In an analysis of the Sperry generator it will be seen that the wire which is to revolve in the presence of the field magnets, is placed at a good distance from the axis of rotation in such a manner that a high peripheral velocity is obtained with a comparatively low rate of revolution of the armature shaft, thereby wasting as little as possible in friction at the journals; and depreciation of the wearing parts of the machine is avoided. Secondly, the presenting the greatest possible percentage



THE SPERRY DYNAMO FOR ELECTRIC LIGHTING.

of this generating conductor to the magnetic masses or pole pieces of the field magnets compels the induction in the space occupied by the generating conductor to be the highest possible, and at the same time makes the resistance of the magnetic circuit of the machine the lowest possible.

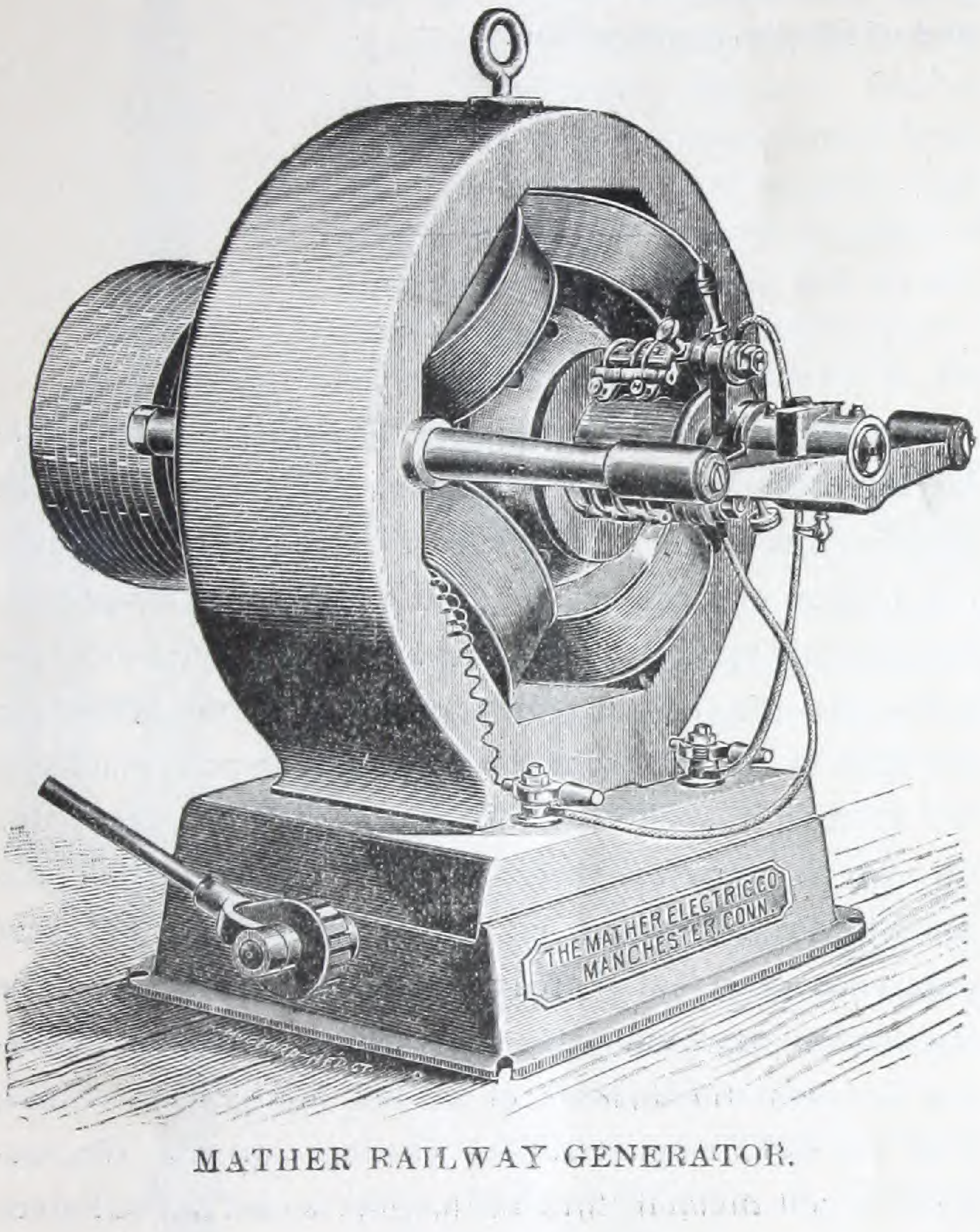
The entire absence of overlapping of the coils is of great practical value. In case of injury sustained by one coil it will not cause the destruction of the whole armature, as the injured part can easily be removed and replaced without disturbing any other coil and without unwinding the whole armature down to this point, as in case of most forms of the cylindrical armature.

The leaving of the inside of the armature free to the pole pieces is valuable for ventilation, and in thus keeping the armature cool its electrical resistance is reduced and the danger of burning is avoided.

The dynamos are so constructed as to be operated several in series upon a single circuit. This greatly reduces the expenses of construction, as modern practice in insulation admits of high electromotive forces being employed. The total electromotive force upon the line being generated at several points is considered more reliable than when generated within the terminals of a single machine.

The plates of the armature core are made of thin iron, well annealed, and each carefully insulated from the other, and the whole mass supported by bolts which project from the edge and which are used to support the whole to the gun metal spider by means of which it is mounted upon the armature shaft.

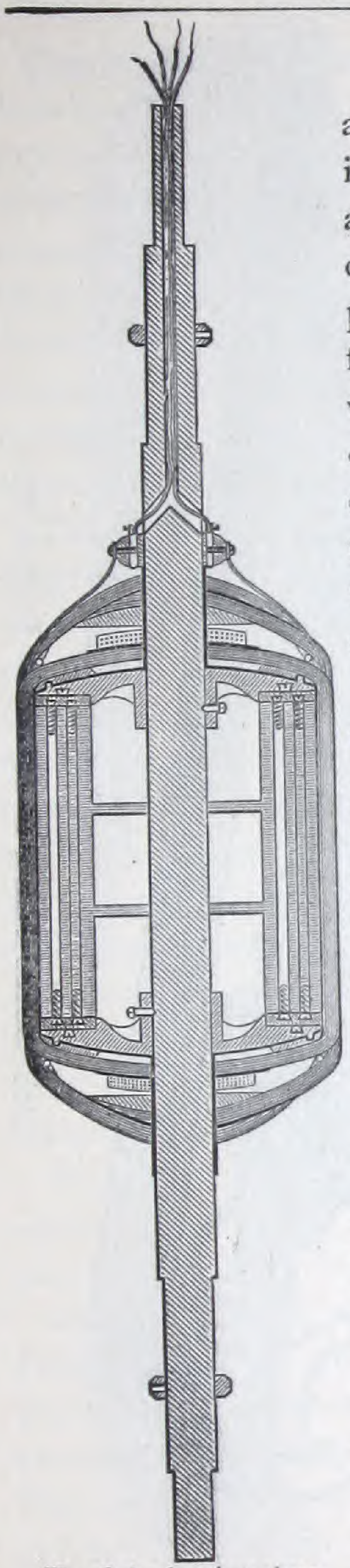
The armature is covered with a coating of non-combustible and indestructible substance, the basis of which is



MATHER RAILWAY GENERATOR.

asbestos. This substance has a very high insulating property, and cannot become charred by any temporary overload. The commutator is of the usual form, mica being employed as insulation throughout. It is very durable and of simple construction.

The Mather Electric Railway Generator.—Recognizing the demand for power transmission by means of the electric current, the Mather Electric Company has brought out a series of machines for that purpose. The generators are built up to 30,000, 50,000 and 75,000 watts with four poles, and 180,000 watts with six poles. Drum armatures are used in all the machines. In the four-pole machines the winding is such that the current has but two paths through the armature wires, and by a special method, devised by Prof. Anthony, no two wires having any great difference of potential are brought near each other. The illustration represents the 75,000-watt generator showing the general character of all the four-pole machines, with the field magnet in one casting. In the 180,000-watt six-pole machine the field magnet is cast in two halves but divided through the middle of two opposite poles instead of across the magnetic circle.



The Schuyler Armature.

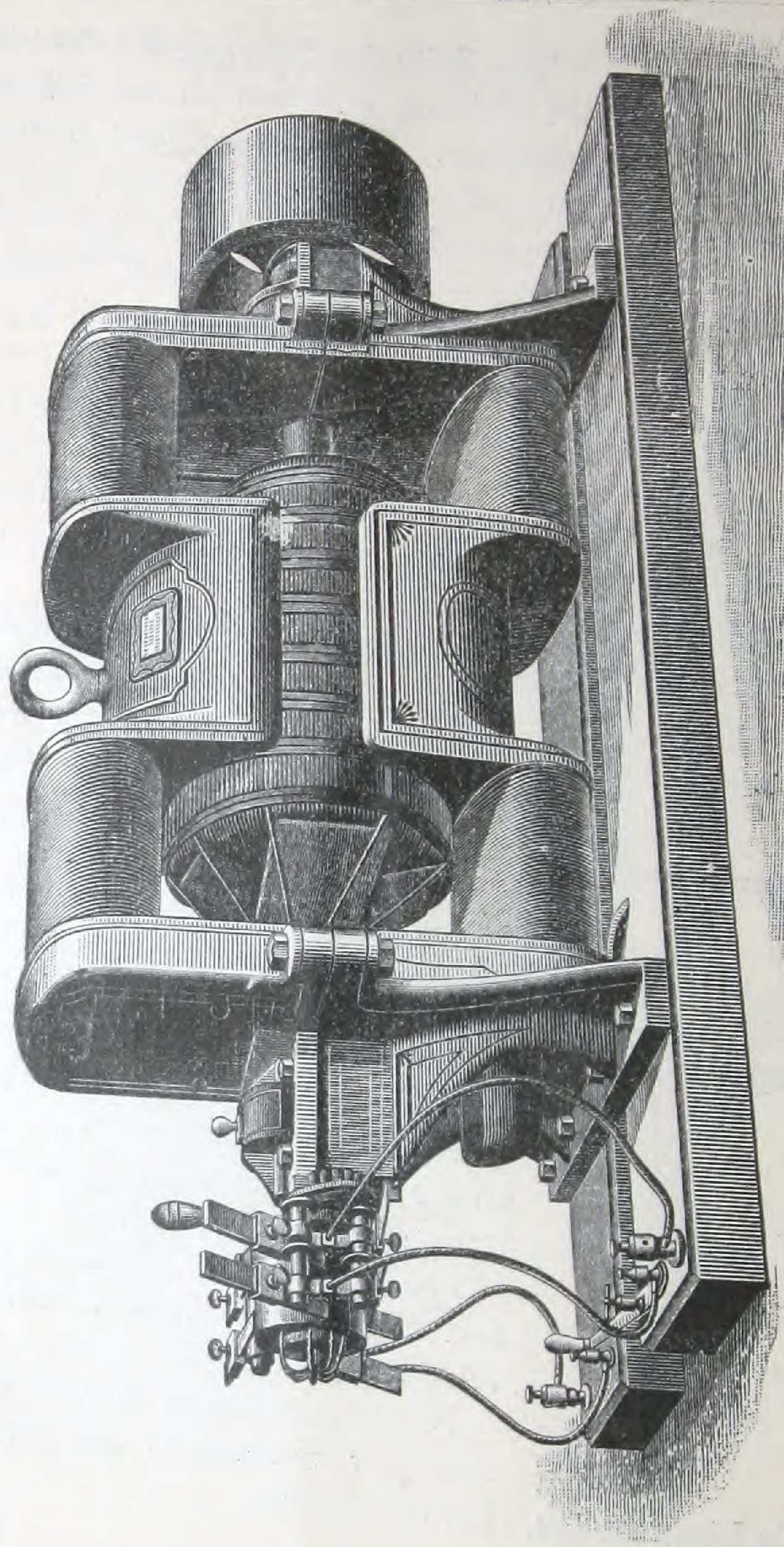
The Schuyler Dynamo for electric arc lighting is shown on the following page. It is of original design and of simple construction, being composed substantially of but three parts, — armature, top and bottom fields. It is of the open circuit type, which is acknowledged to give some of the best results in both economy of operation and brilliancy and steadiness of light. One especially important feature of this dynamo is the armature.

The Safety Ventilated Armature of the Schuyler dynamo (see accompanying illustration) is of the drum type and of such construction that it permits the passage of air through it from end to end, which serves to keep the armature cool at all times, and renders overheating and consequent burning-out impossible.

The drum form used in the Schuyler is capable of developing the greatest amount of energy; but its form and air spaces are absolute protection against overheating.

The armature is entirely simple, and at the same time is compact, reliable, and efficient.

Another valuable feature of the Schuyler dynamo is the self-lubricating bearings.



THE SCHUYLER ELECTRIC DYNAMO.

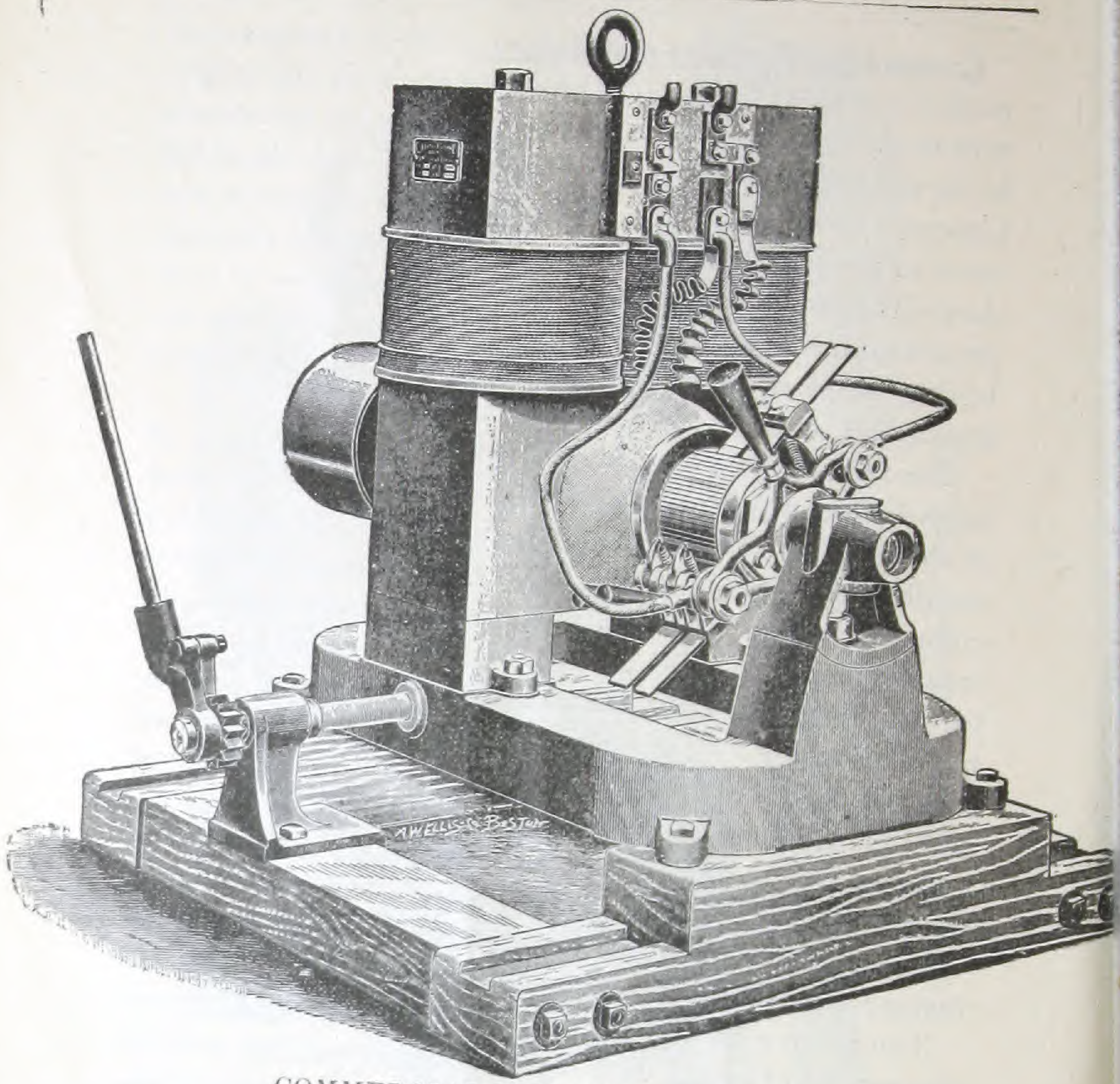
Commercial Dynamos and Motors.--These dynamos and motors are all of the single U undertype, with the armature at the bottom, which theory and experience has shown to be most desirable, for both mechanical and electrical reasons. The aim in the design of these machines has been to produce only the best, and it is believed that this determination, coupled with our novel methods of construction, have resulted in a line of dynamos and motors, having more desirable features, viewed from the user's standpoint, than any now on the market.

The field magnet frames of all machines are made of forged wrought iron throughout, no cast iron being used in them. Lighter, more sightly, more efficient machines are obtained, as a result of this construction. No other company in the United States is using forged wrought iron exclusively for field magnet frames. Gramme armatures of large diameter are used in machines from $\frac{1}{4}$ to 10-horse power, giving ample room for the many turns of wire required on these small machines for high pressure and insuring non-liability to burn-outs and ease of repair.

Armatures in machines from 1 to 10-horse power are wound for the 110-volt pressure with but one layer of wire, and for the 220 and 500 with but two layers, another feature which renders burn-outs unlikely and repairs easy.

The air-gap in the above sizes of machines is much shorter than is usual with smooth core armatures, and the amount of field exciting force required consequently small.

Machines above 10 horse-power in capacity have the Siemens type of armature, the diameter of which is so chosen, in each case, that the air gap may be made as short as the demand for a fixed neutral point will permit. The point of commutation is constant under all changes of load, within the capacity of the machines, due to the



COMMERCIAL DYNAMO AND MOTOR.

great strength of the field magnets and few turns of wire on the armatures. Our incandescent dynamos and power generators are accurately compounded and are guaranteed to be automatic. Motors and electro-plating machines are simple shunt wound. The bearing sleeves in all machines are made of phosphor bronze, and commutators of pure, hard copper. Bearings in all machines are self-oiling

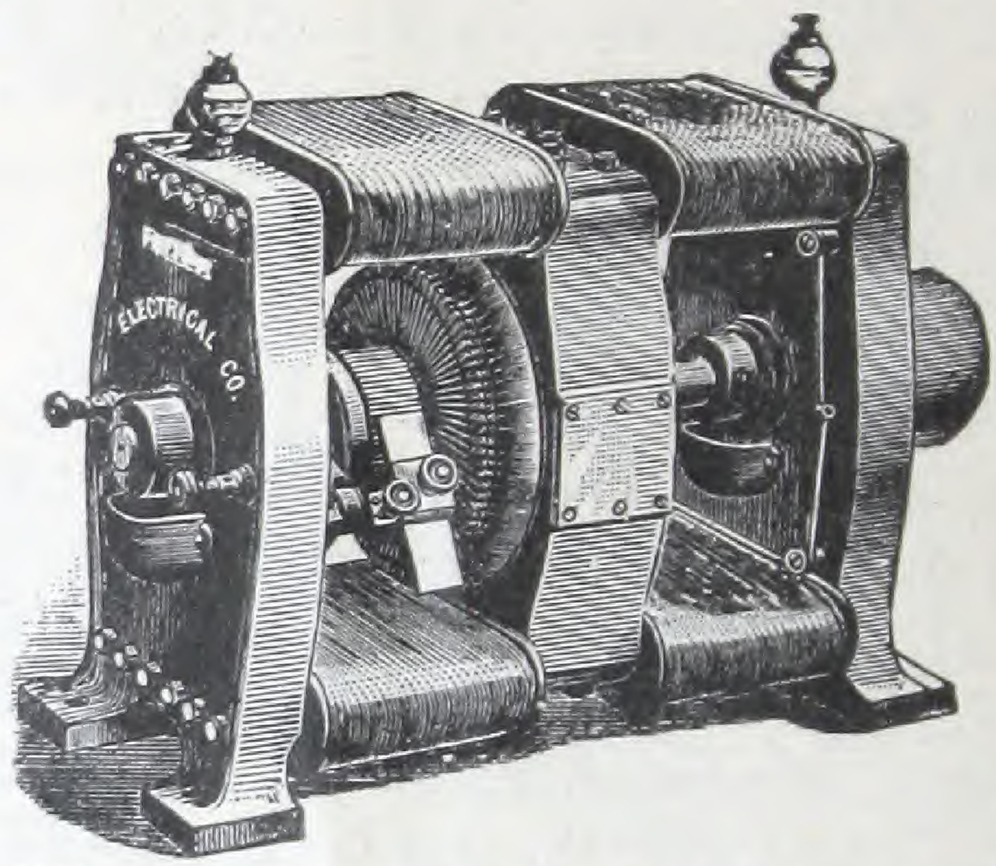
The New American Dynamo. — The following engraving gives a very good idea of the size and general appearance of the new improved dynamo. It is of the Gramme type.

The heart of the Dynamo is the armature. It is in this vital part that Mr. Wood has made his greatest improvements, and given the American system one of the most perfect, substantial and reliable armatures known to electrical science.

The Armature offered by the AMERICAN COMPANY is of different construction from any other, being made in the form of a ring of soft iron wire. It is then closely covered with coils of carefully insulated copper wire. These coils are so insulated and placed in the new armature as to prevent the possibility of a short circuit between them.

The commutator plays an important part in the protection of the armature. The narrow copper plates of which it is made are thoroughly insulated from each other with fire-proof material. It is so constructed that one or more of its sections may be readily removed, without interfering with the remaining ones. Where the ends of the armature coils are connected to the commutator clamps, they are enlarged so as to increase their strength and lessen their tendency to vibrate or break. These enlarged ends are connected with the radial arms of the commutator, by a screw clamp of patented design. This enables any section or coil in either the commutator or the armature to be easily removed or replaced without seriously interfering with any other part of the dynamo.

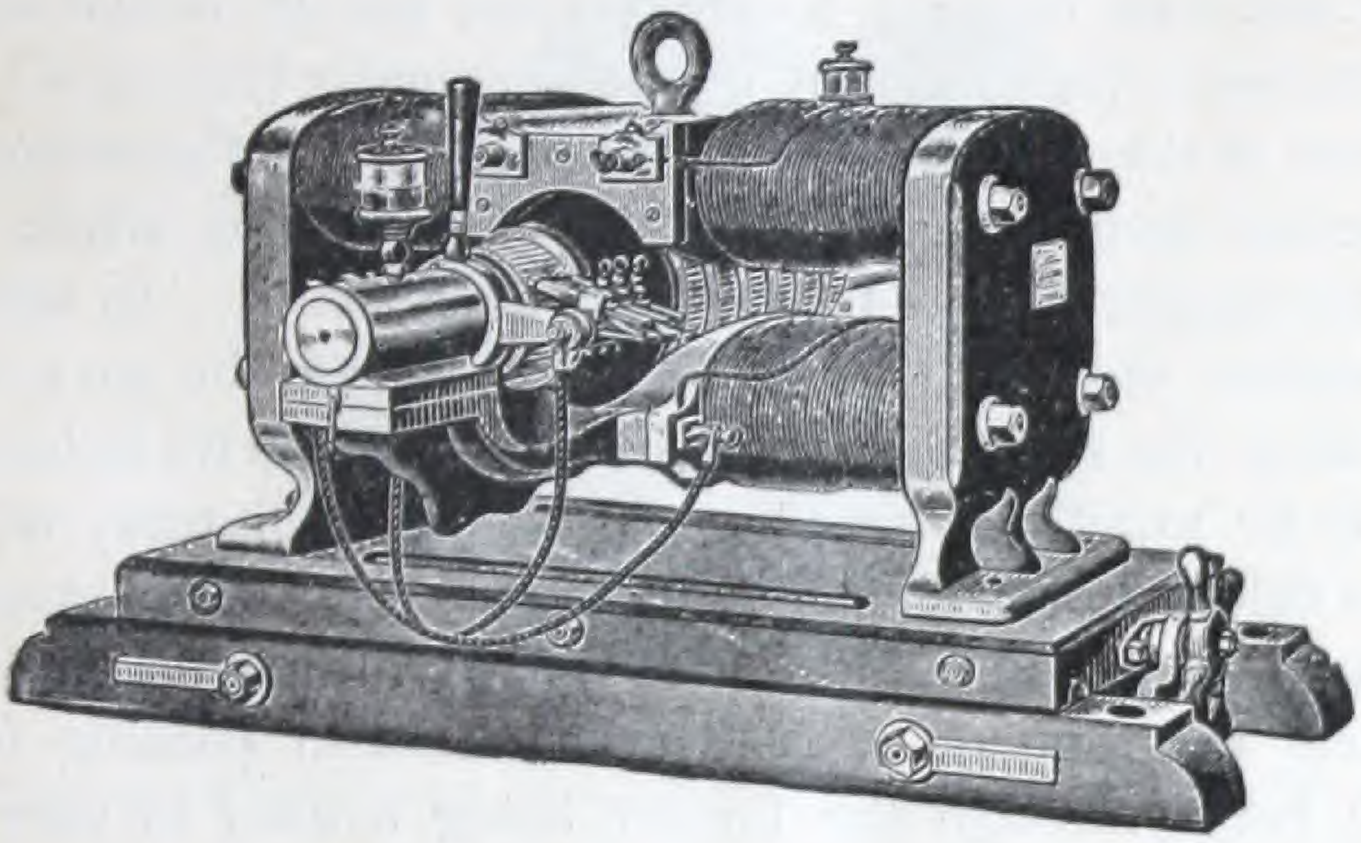
The destruction of any part of the armature of any other system of electric lighting would immediately disable the machine, and render it useless until replaced by a new one. This would cost several hundred dollars, while the price of repairing the American armature would be very trifling on account of the great number of individual coils and the ease with which any one of them can be removed or replaced. The centre is composed of a gun-metal spider so constructed as to give perfect ventilation,



THE NEW AMERICAN DYNAMO (Wood's Patents.)

and the greatest strength with the least weight. The spider also absorbs any undue heat that may be electrically developed in the ring. This heat is so quickly dispersed by the current of air produced that the tendency to overheating is entirely removed. The manner of handling the brushes in the American dynamo is another point of superiority. They are quickly and rapidly adjusted, do not spark, are easily trimmed and well protected.

The Fontaine Crossing Co.'s Low Speed Dynamo is shown in the accompanying engraving. It is designed especially to be used on steamboats and isolated plants in general, and so far has proved a success. One of these dynamos is now in use on board the E. C. Pope, the largest freight steamer on Lake Michigan, operating the equivalent of 225-16 c. p. lamps at a speed of only 450 revolutions per minute.



The Alternating Current System.—This system has many points of superiority over the direct system, especially for incandescent lighting, and in arc lighting it consumes the carbons with much more evenness than the direct current, thus giving them a much longer life.

In the alternating current system, by the use of a converter, it may employ a high tension of current in the conductors and a low tension in the lamp; that is, it may employ for ordinary distances—one or two miles—when there is a tension of 100 volts in the distribution circuit, and yet the same dynamo may send out a portion

of the current raised to a tension of 2,000 or 3,000 volts to a much further distance; also, it may be employed to deliver currents to both 50 and 100 volt lamps from the same conductor.

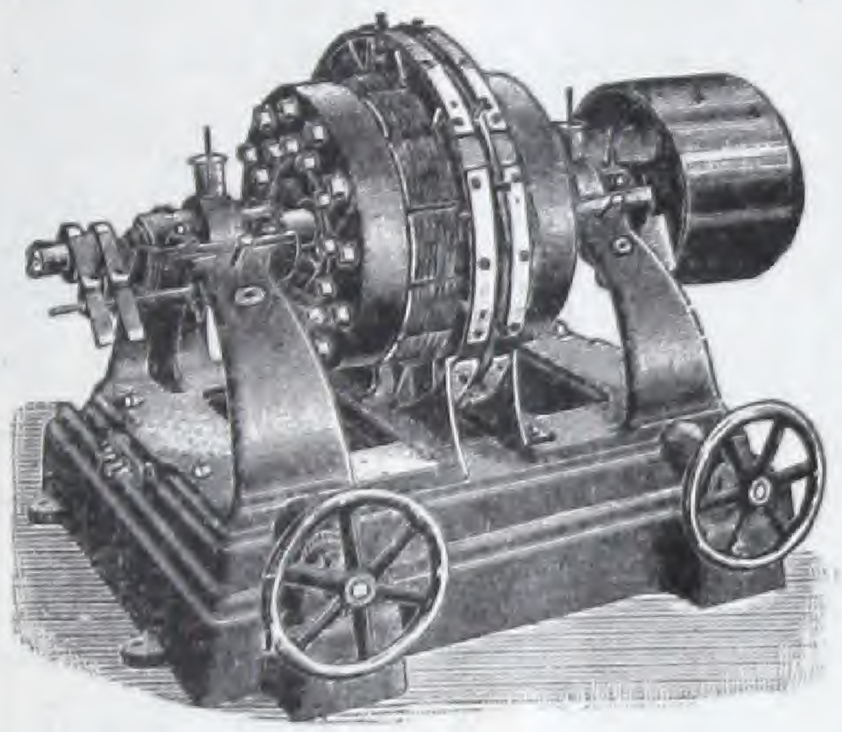
In the alternating current machines, electric currents are induced in the armature coils by causing the amount of magnetic induction through them to alternately increase and decrease. Most frequently there is not simply an alternate increase and decrease, but an actual rapid reversal in the direction of the magnetic induction. In some of these machines, as in the majority of continuous-current dynamos, the armature part rotates while the field-magnet part of the machine stands still. In others, however, the armature part—that is to say, the part comprising the coils through which the magnetic induction is to be rapidly reversed or varied—is a fixture, whilst the field-magnets are made to rotate. In a third class of machines both armature part and field-magnet part are fixed, the amount of magnetic induction passing from the latter through the former being caused to vary or alternate in direction by the revolution of appropriate pieces of iron.

The Brush New Alternating Current Dynamo.—The underlying principle of the remarkable "Coreless" dynamo here illustrated, was discovered and applied by Mr. Brush more than 10 years ago, and new demands have now called for its extended application on a regular scale.

The first glance at the dynamo shows that it is novel, compact, symmetrical and strong. A brief examination shows that it is of the alternating type; that its field magnets are many and carried by the shaft; that the

armature is fixed and absolutely free from any magnetic material; that its parts are easily accessible, and that an armature coil may be cut out, removed or replaced without stopping the machine.

The machine chosen for illustration and description has an output of 60,000 watts; it supplies current for a thousand 16-candle power lamps.

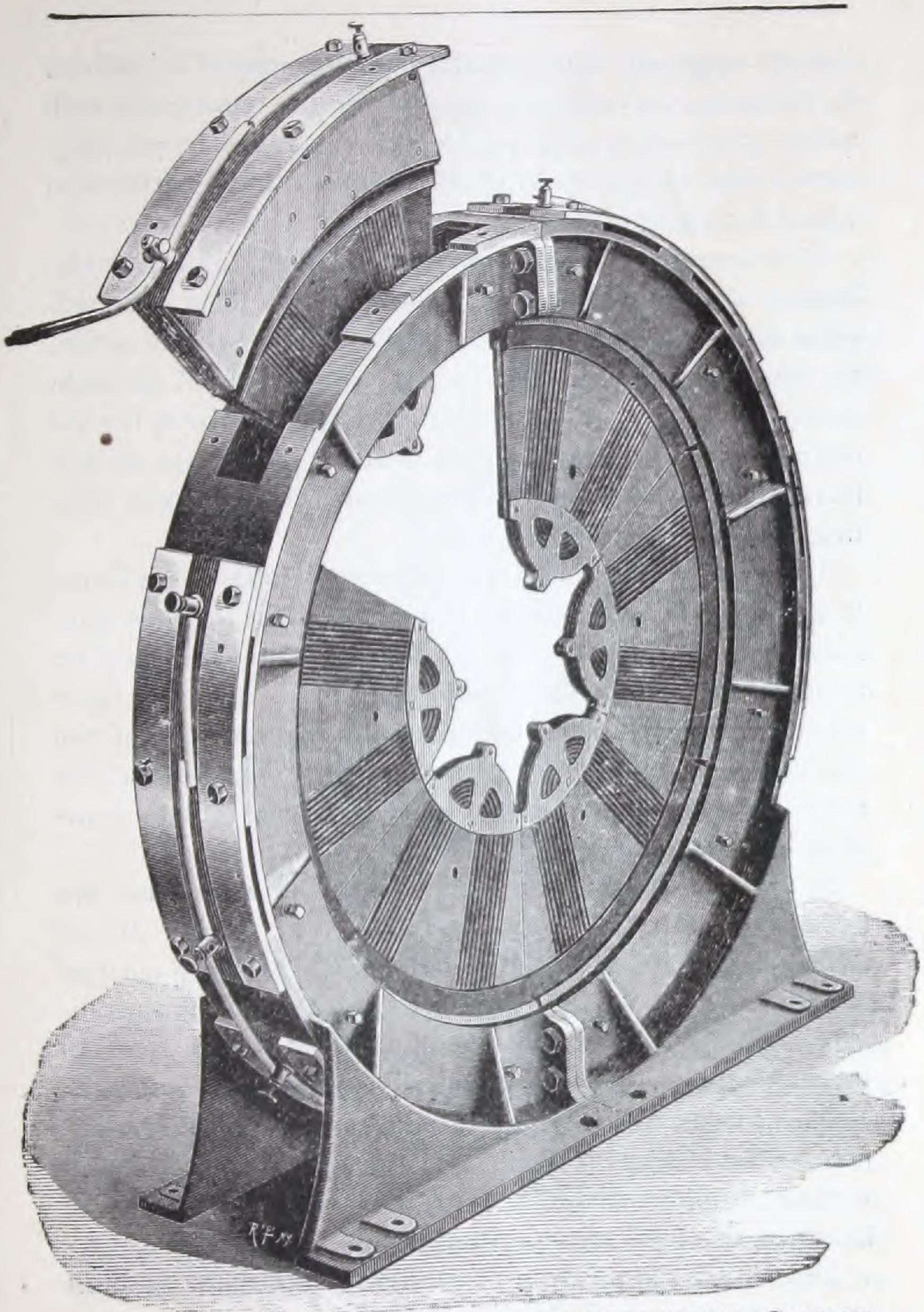


The shaft bearings, bearing standards, base plate and armature slides are cast in one solid piece. The center line of the shaft is 16 and 11-16th inches above the surface of the base plate, high enough for access to all parts of the dynamo and low enough for steadiness and freedom from strain on foundations. The 4-inch steel shaft (tapering to three and a half inches in the bearings), carries two heavy cast-iron yoke pieces, 27 inches in diameter. To each of these are screwed, at equal radial and circumferential distances, the wrought-iron cores of 12 magnets of alternating polarity. The two yoke pieces, with their bolts, washers, etc., weigh about 950 pounds; the magnet cores, 308; the magnet wire, 400. Thus the whole rotating mass of cast-iron, wrought-iron and copper,

acts as a fly-wheel weighing more than 1,700 pounds' and tending to neutralize any variation in the speed of the prime generator. As the nominal speed of the machine is fewer than 1,100 revolutions per minute, the structural strength is more than sufficient to meet all demands made by centrifugal force. Further than this, the mechanical stress is less when the magnets are excited than when the alternator is running without load, as the lines of magnetic force between the faces of opposing poles, tend to counteract centrifugal force.

But the most interesting part of the alternator is the fixed armature, shown in the full page engraving. The vertical disc is occupied by flat armature coils, made of insulated copper ribbon wound on porcelain cores. The copper ribbon of each coil is reinforced on either side with strong insulating material of the same thickness as the porcelain. One of these reinforcements is grooved and the other tongued. The coil, consisting thus of core, ribbon and reinforcements, has an angular width of 60 degrees. The upper part of each face of each coil is covered with an insulating plate 5-16th of an inch thick. The coil thus built up and insulated is set in German silver holders, cut from true turned rings and held together by sunk-headed screws, as shown in engraving. Each terminal of the copper ribbon connects with a binding post as shown.

The six armature coils thus mounted are carried in a German silver frame consisting of two semi-circles bolted together on the line of the vertical diameter. The cross-section of this ring frame is girder-like. Into the slots of the frame-slip the six-mounted armature coils, the tongue on the edge of the one engaging with the groove on the edge of the next. The coils thus thrust into the



ARMATURE OF THE BRUSH ALTERNATING-CURRENT DYNAMO.

intense magnetic field constitute a disc, 9-16th of an inch in thickness, and with an opening in the centre through which passes the revolving shaft. As there is no magnetic metal in the armature there are no local currents to waste the energy.

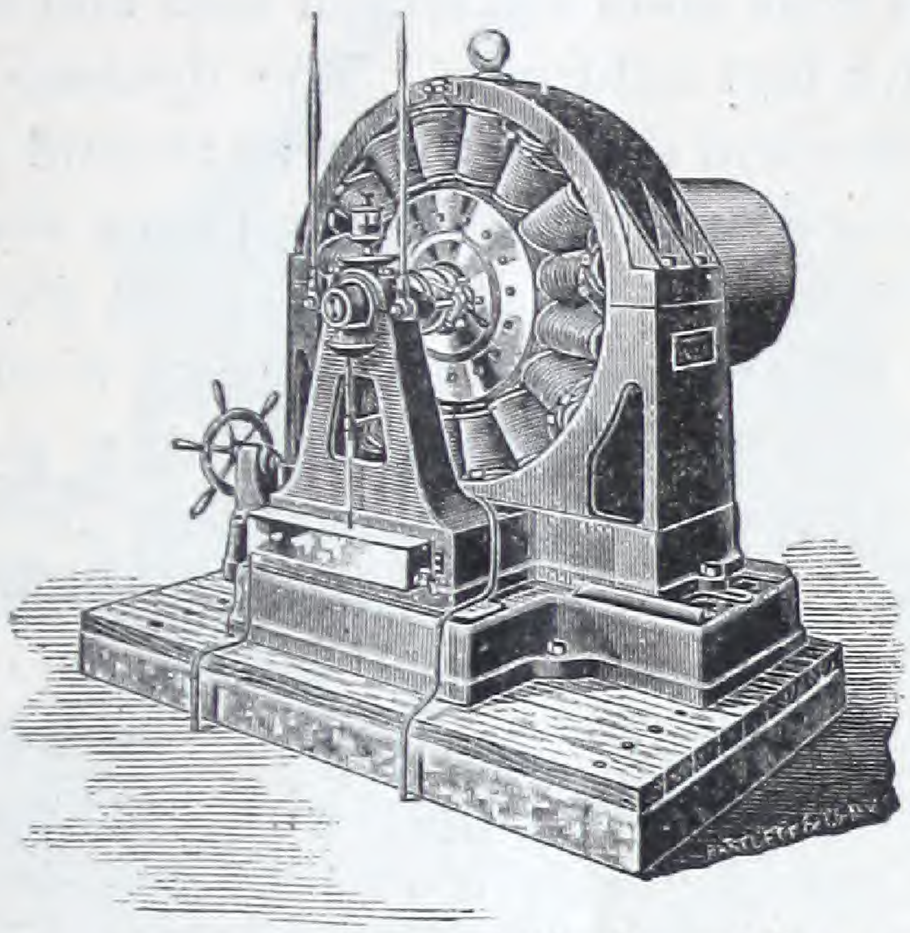
The several coils are insulated carefully, and the stationary armature, as a whole, is insulated from the bed-plate on which it rests. The coils are joined in series, the binding-posts adjacent to any radial line of division between the two coils constituting fixed terminals for the main line. There is no commutator; there are no collecting brushes to take the alternating current from rotating parts.

The low resistance of the armature coils is evident. It would seem impossible for one of them to burn out; none ever has burned out. But if one should, it may be removed and a new one readily put in its place in three minutes, or the injured coil may be shunted out of the circuit and the dynamo kept running with the other five until the time for shutting down. The coil section complete weighs only about 20 pounds.

In action, the 24-field magnets of the alternator are excited by the direct current from an 11-inch Brush dynamo of the well-known form. This exciting current is carried to the brushes that rest upon the two un-cut insulating rings, and thence through the hollow shaft to the magnets. A rheostat worked by hand or automatically is placed in the shunt-circuit around the field magnets of the exciter, so that perfect regulation is secured without readjustment of the brushes or any necessity of handling the high-tension alternating current.

The Brush-Pfannkuche "coreless" alternator is built at present for an E. M. F. of 2,000 volts.

The Westinghouse Alternating Current Dynamo for generating the alternating current is represented by the accompanying illustration. It is apparent at a glance that it is very different in its principles and construction from the ordinary machine. In its mechanical and electrical details, it represents a simplicity far greater than is possible with any dynamo for generating a direct current. The field is composed of a series of radial pole pieces having alternate polarity, the cores of which are cast



The Westinghouse Alternating Current Dynamo.

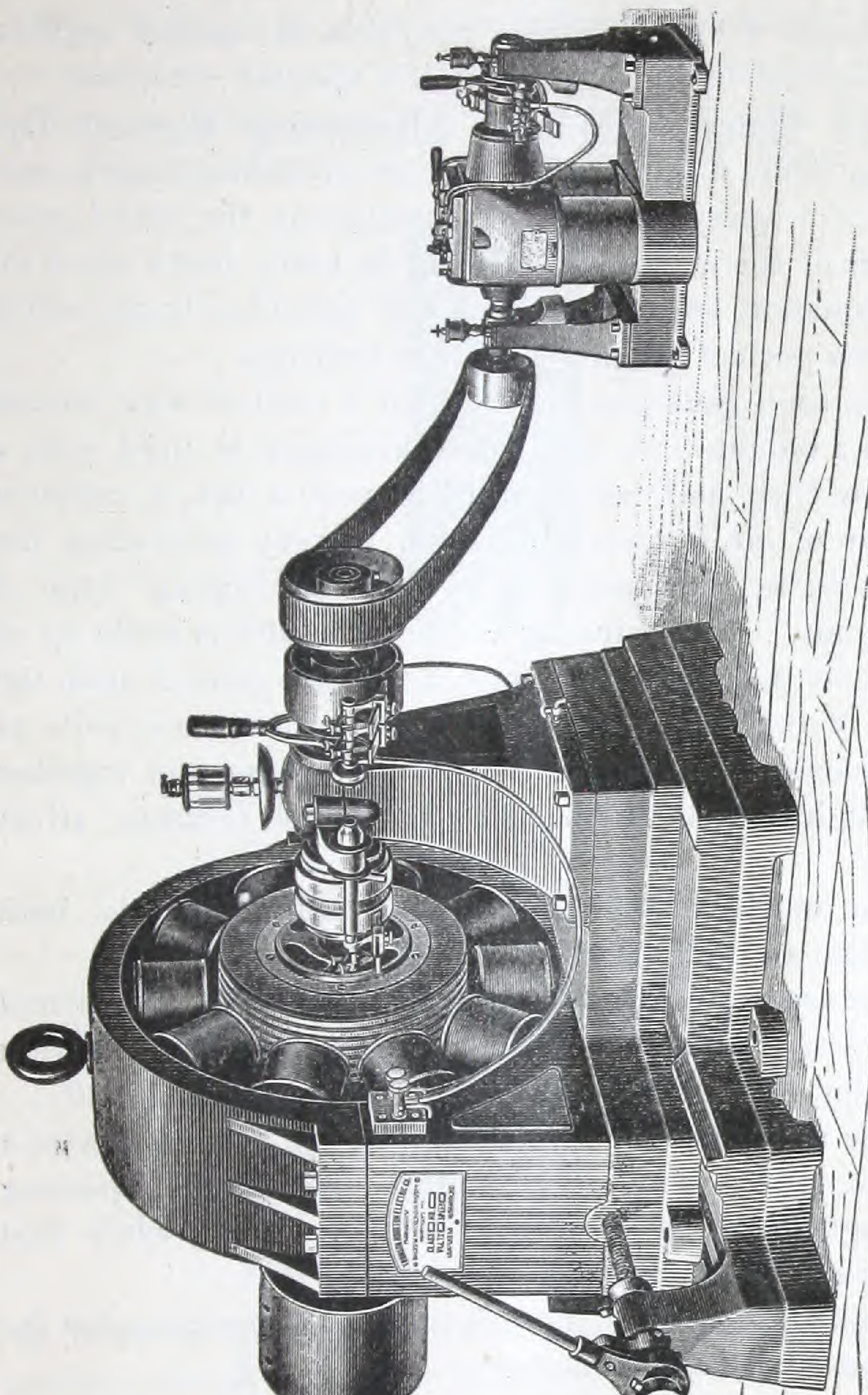
solid with the base and cap respectively. The field coils are a series of bobbins each independent of all the others which are wound on shells, slipped over the pole pieces and held up by bolts at the periphery. These bobbins being supplied with a feeble current from the exciter are of course subject to no natural deterioration and are not liable to accident. They can only be damaged by extraneous carelessness, and, when such is the case, the cap of the dynamo is removed and any bobbin taken

out and replaced in a few moments. The armature is removed in the same manner, as the whole structure of the dynamo, including the pole pieces and the bearings, parts along a horizontal plane through the shaft.

The engraving shows the side of the dynamo which carries the collecting ring; the other side has a similar bearing, beyond which is an over-hung pulley. This pulley is of compressed straw-board, which in experience is found to exceed all other material for belt traction. The dynamo rests upon a cast iron base and is adjustable by means of a belt tightener. The dynamo can run in either direction and stand either way around on the base. This of course adapts it universally to any situation.

The armature is a structure of great directness and simplicity. The body of the armature is of laminated iron plates freely perforated for ventilating purposes. A single layer of wire is wound in flat coils back and forth across the face of the armature in a direction parallel to the shaft, being retained by stops on the ends of the armature. Mica and other adequate insulation is provided and the whole is wrapped with binding wire. A ventilator is attached to each end of the armature and draws a strong current of air through it.

The observer will be struck by the simplicity of the winding on an alternating current armature as compared with that necessary in the direct current machines. The total weight of copper on a 750-light armature is 16 lbs., disposed in a single layer, which being on the surface is readily kept cool, and which can be inspected for deterioration or flaws of any character. A direct current armature of type most generally in use of 750 lights capacity on the other hand carries more than 10 times this amount of wire.



THOMSON - HOUSTON ALTERNATING CURRENT DYNAMO, WITH EXCITER.

The armatures are uniformly wound to deliver 1 000 volts, and a higher voltage than this, for special circuits, is obtained by raising through a special converter.

The Thomson-Houston Alternating Current Dynamo (shown in the engraving on preceding page), consists of a heavy casting which supports the radial pole-pieces of the machine. It may be easily taken apart for examination, and is provided with spherical boxes, which allow a perfect allignment of the bearings.

On each pole-piece is slipped a coil of wire wound upon a bobbin. A laminated armature is used with a hollow core, and, being supplied with a fan, a constant stream of air is forced through, thereby preventing the excessive heating common to the "alternating" type of dynamos. The winding on the armature is made up of flat coils wound upon a form and then placed upon the face of the armature core; there are as many coils as the machine has poles; they are all connected together and tightly held in place by bands of German silver wire.

The machine has a composite winding—that is, both separate and self-exciting fields.

The separate-exciting part is supplied by a direct current from a small motor-type dynamo, driven by a belt from a pulley at the commutator end of the armature-shaft.

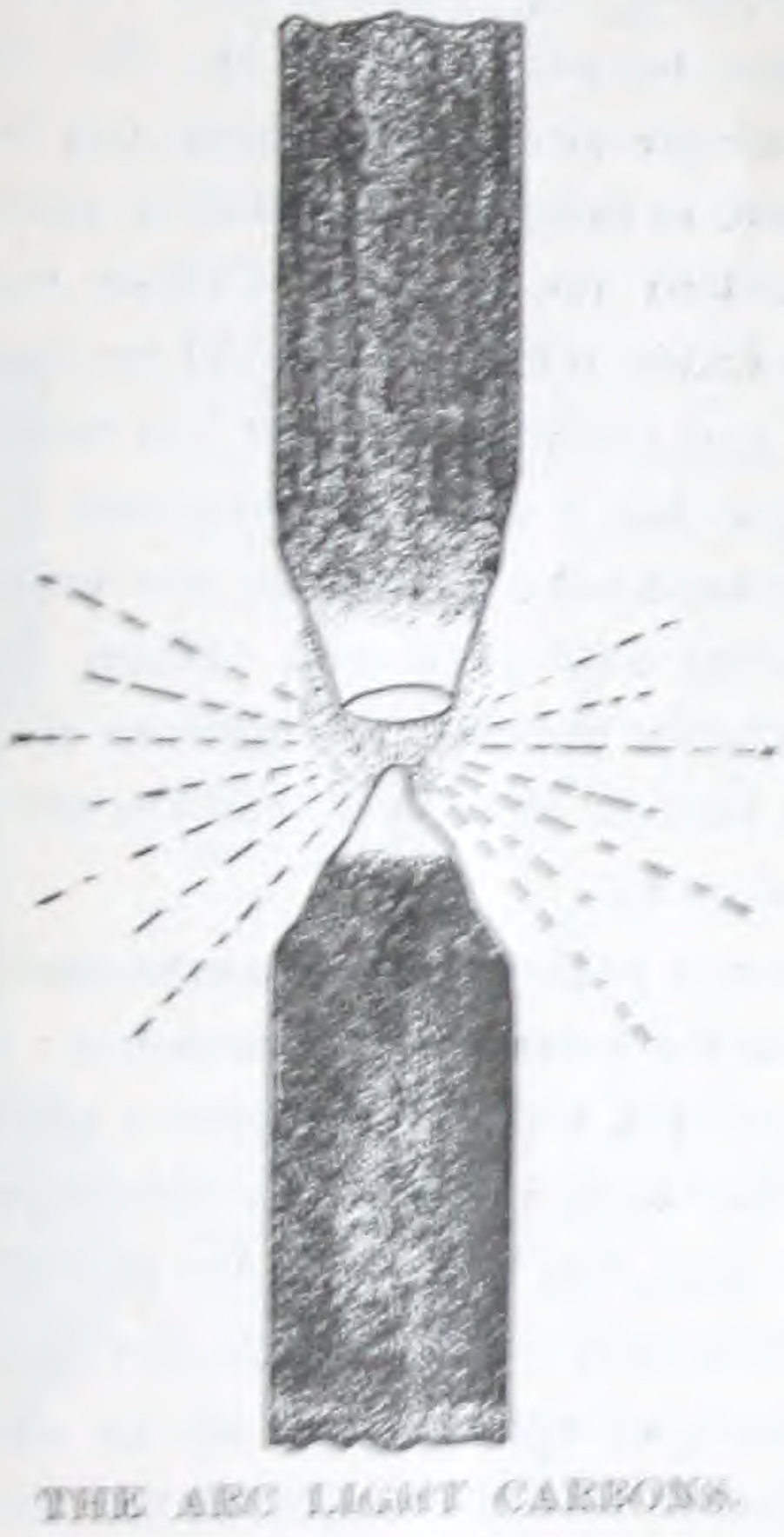
The main current, before going to the line, passes to a commutator so connected that the current passing through the series winding is a direct current, while that in the outside circuit is alternating.

This machine may, by this means, be compounded for any per-cent. loss in the lines.

It is, on this occount, very valuable for central station work and long-distance incandescent lighting.

ELECTRIC LAMPS.

The Voltaic Arc.—If two pointed pieces of carbon are joined by wires to the terminals of a powerful voltaic battery or other generator of electric currents, and are brought into contact for a moment and then drawn apart



THE ARC LIGHT CARBONS.

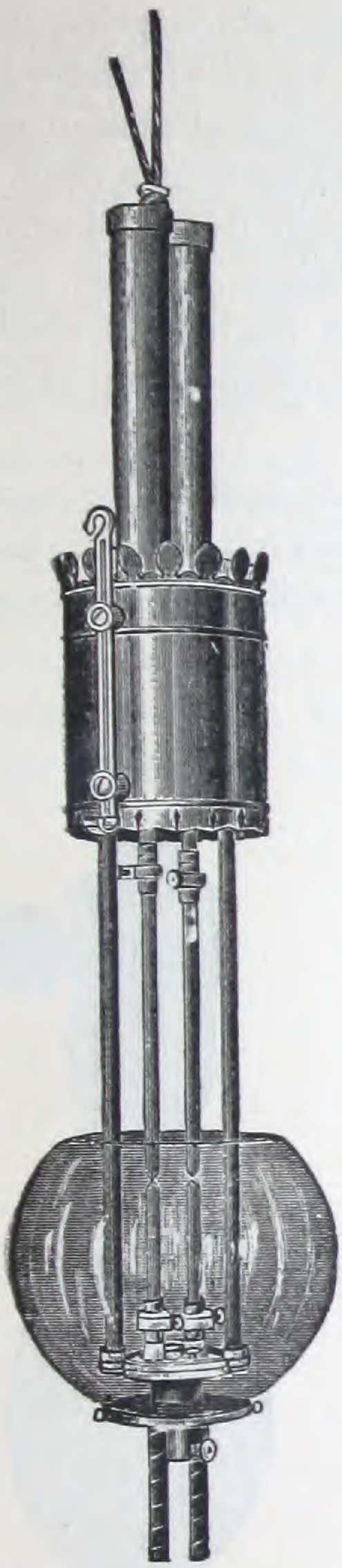
to a short distance, a kind of electric flame called the *voltaic arc* is produced between the points of carbon, and a brilliant light is emitted by the white hot points of the carbons.

Before contact, the difference in potential between the points is insufficient for the current to leap across the air-space, therefore the carbons must be made to touch one another before the current can be established.

On separating the carbons the momentary extra current due to self-induction of the circuit, which possesses a high electromotive force, can leap the short distance, and in doing so volatilises a small quantity of carbon between the points. Carbon vapor being a partial conductor, allows the current to continue to flow across the gap, provided it is not too wide; but as the carbon vapor has a very high resistance it becomes intensely heated by the passage of the current, and the carbon points also grow hot. Since, however, solid matter is a better radiator than gaseous matter, the carbon points emit far more light than the arc itself, though they are not so hot.

The upper or positive carbon is consumed about twice as rapidly as the lower or negative carbon; the lower one becoming pointed, while in the upper a crater is formed. With the alternating current both carbons are consumed at the same rate, and both retain the pointed form, which permits a free radiation of the light in every direction.

The quantity of light emitted by an electric lamp is disproportionate to the strength of the current; and is, within certain limits, proportional to the square of the heat developed, or to the fourth power of the strength of the current.



The Arc Lamp now in general use consists simply of two hard carbon rods and a mechanical contrivance to feed them—that is, push them forward as fast as needed.

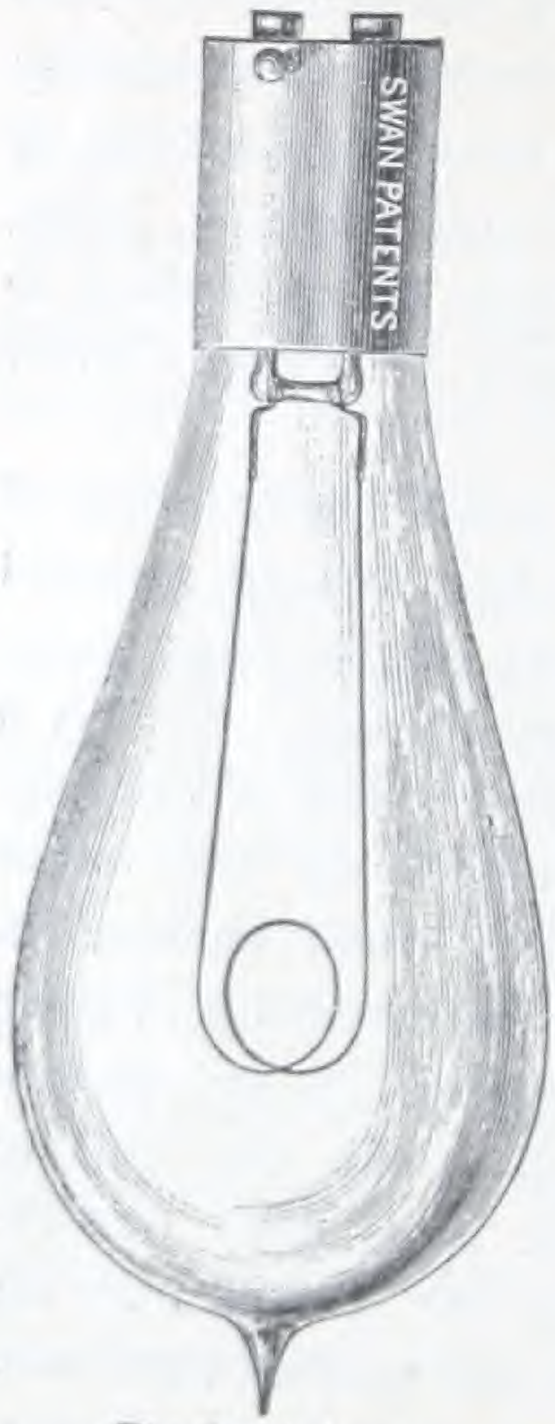
It is requisite that the mechanism should start the arc by causing the pencils to touch and then separate them to the requisite distance for the production of a steady arc; the mechanism should also cause the carbons not only to be fed into the arc as fast as they consume, but also to approach or recede automatically in case the arc becomes too long or too short; it should further bring the carbons together for an instant to start the arc again if by any chance the arc goes out.

There are a great many forms of arc lamps, but the one in general use by a number of the large companies is the clutch lamp. This is a simple device, and is that of employing a clutch to pick up the upper carbon holder, the lower carbon remaining fixed. In this kind of lamp the clutch is worked by an electro-magnet, through which the current passes. If the lamp goes out the magnet releases the clutch, and the upper carbon falls by its own weight and touches the lower carbon. Instantly the current starts round the electro-

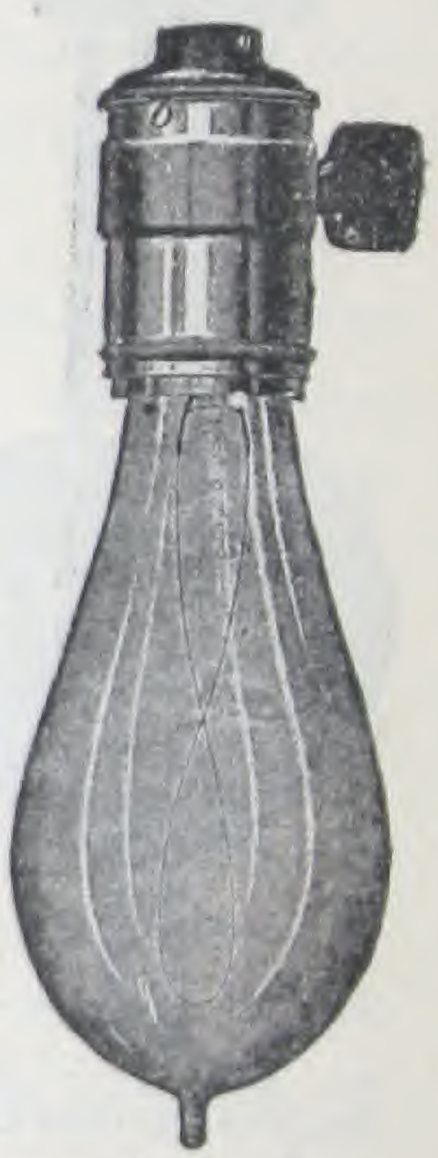
magnet, causing it to act on the clutch which grips the carbon-holder and raises it to the requisite distance. Should the arc grow too long the lessening attraction on the clutch permits the carbon-holder to advance a little.

The lamp in the illustration is one of the Brush Electric Co.'s make, and is a double-carbon lamp. When one carbon has burned out, the current is shifted automatically to the other, thus making the life of the lamp twice as long.

Incandescent Lamp.— The incandescent lamp consists of a glass globe or bulb, from which the air has been exhausted, containing a carbonized fibre of bamboo.



The Brush Lamp.



Thomson-Houston Lamp.

This carbonized fibre is attached to two platinum wires fused in the glass, the free ends of the wires being connected to the copper sockets of the lamp, which are insulated from each other by plaster of Paris. The wires are then connected to the external circuit. A 16-candle power lamp, with an E. M. F. of 110 volts, has a resistance of about 190 ohms. A lamp will only last a certain number of hours in proportion to the intensity of the current sent through it; therefore it must be renewed as often as it burns out. The average life of a lamp is a little over one thousand hours. The two incandescent lamps shown in the illustration are the ordinary forms used in the Brush and Thomson-Houston system. Ordinary lamps are about 16 candle power, although they are made from 1-2 to 150 candle power.

ELECTRIC MOTORS.

Probably the first electric "motor," in the true sense of the word, was "Barlow's Wheel." About 1826 Barlow discovered that by passing an electric current from the centre to the circumference of a copper disc, placed between the poles of a magnet, the disc would revolve. The current was sent perpendicularly through the disc, from its axis to circumference, when it passed into a cup of mercury. From 1826 to 1832 several motors were invented,—one by Abbe Salvatore dal Negro, professor of natural philosophy at the University of Padua. Botto is said to have invented a motor about 1833. In 1838 Professor Jacobi exhibited his improved motor at St. Petersburg, on the Neva, which propelled a boat 28 feet long, 7 feet wide and 2 feet 9 inches draught, carrying fourteen passengers; it required a battery of 320 Dannells cells to generate the electric current. In 1839 this experiment was repeated with 138 Grove cells; the highest speed attained was about three miles an hour. M. Froment and Count du Moncel were among the early inventors. In 1837 Thomas Davenport, a blacksmith of Brandon, Vt., patented the first electric motor ever invented in this country. Other motors were invented by Professor Page of Washington and Professor Vergnes of New York.

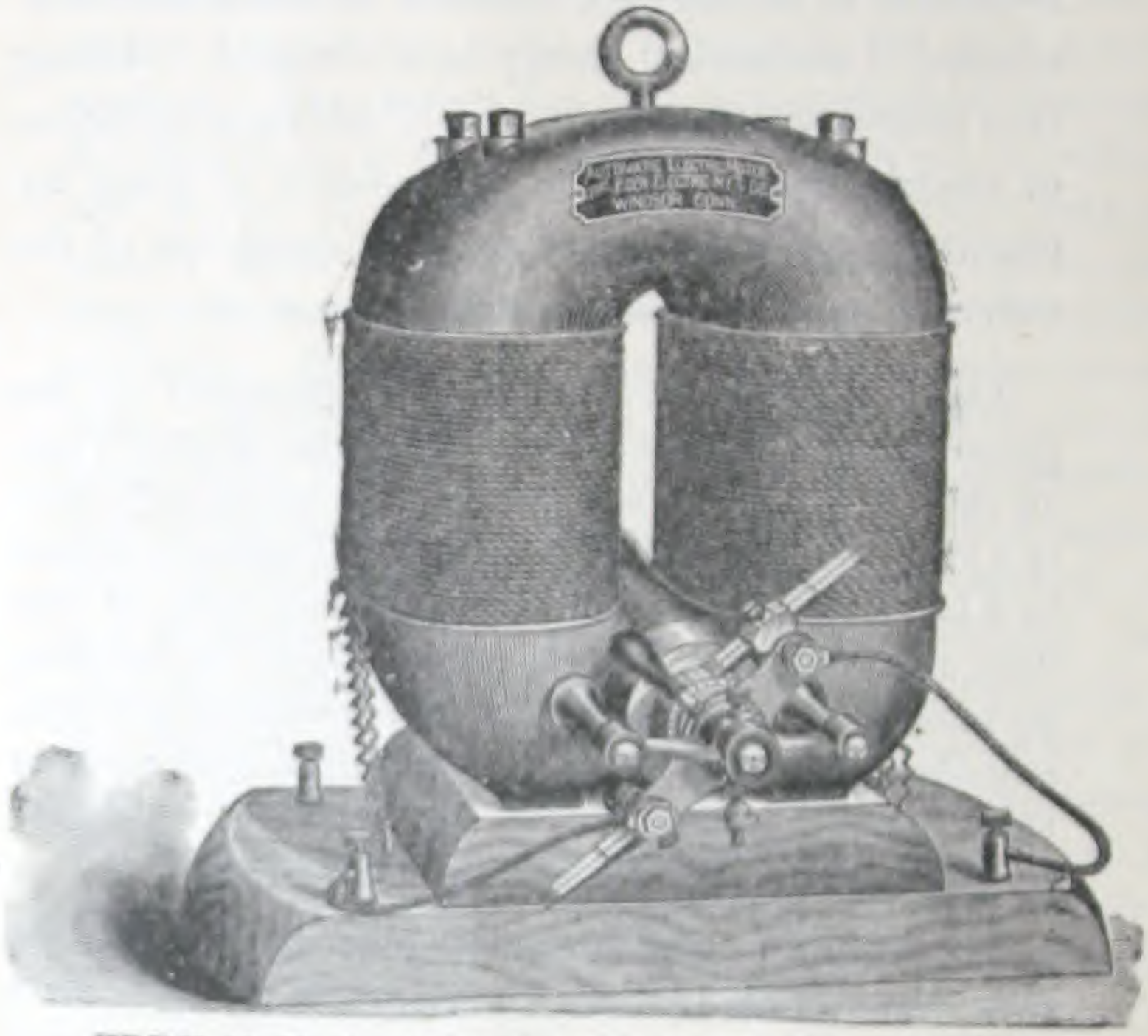
Any dynamo-electric machine can be run as a motor by sending an electric current through it and reversing its motion. Messrs. Siemens claimed to have discovered the principle of the reversability of the dynamo about 1867, but it was not heard of in practical application until 1873. This was at the Vienna Universal Exposition, and was demonstrated by M. M. Hippolite, Fontaine and

Bregnet. In this case a Gramme machine, used as a motor to work a pump, was run by the current produced by a similar machine connected by more than a mile of cable and put in motion by a gas engine. This is claimed to be the first instance of electrical transmission of mechanical energy to a distance. Having thus briefly reviewed the discovery and early invention of electric motors and the transmission of power by electricity, we will proceed to the description of the different so-called systems of the present day.

The Eddy Motor.—This motor is designed on the general principles of construction of the Mather type. In this latter form, it will be remembered that the field is a ring; consequently the field coils cannot be wound in a lathe, and the length and numerous turns of fine wire, required for a shunt machine, make the winding by hand tedious and difficult. It is common to wind a considerable number of wires in multiple, then connect them finally in series to give the requisite resistance; for high potentials this practice is not reliable.

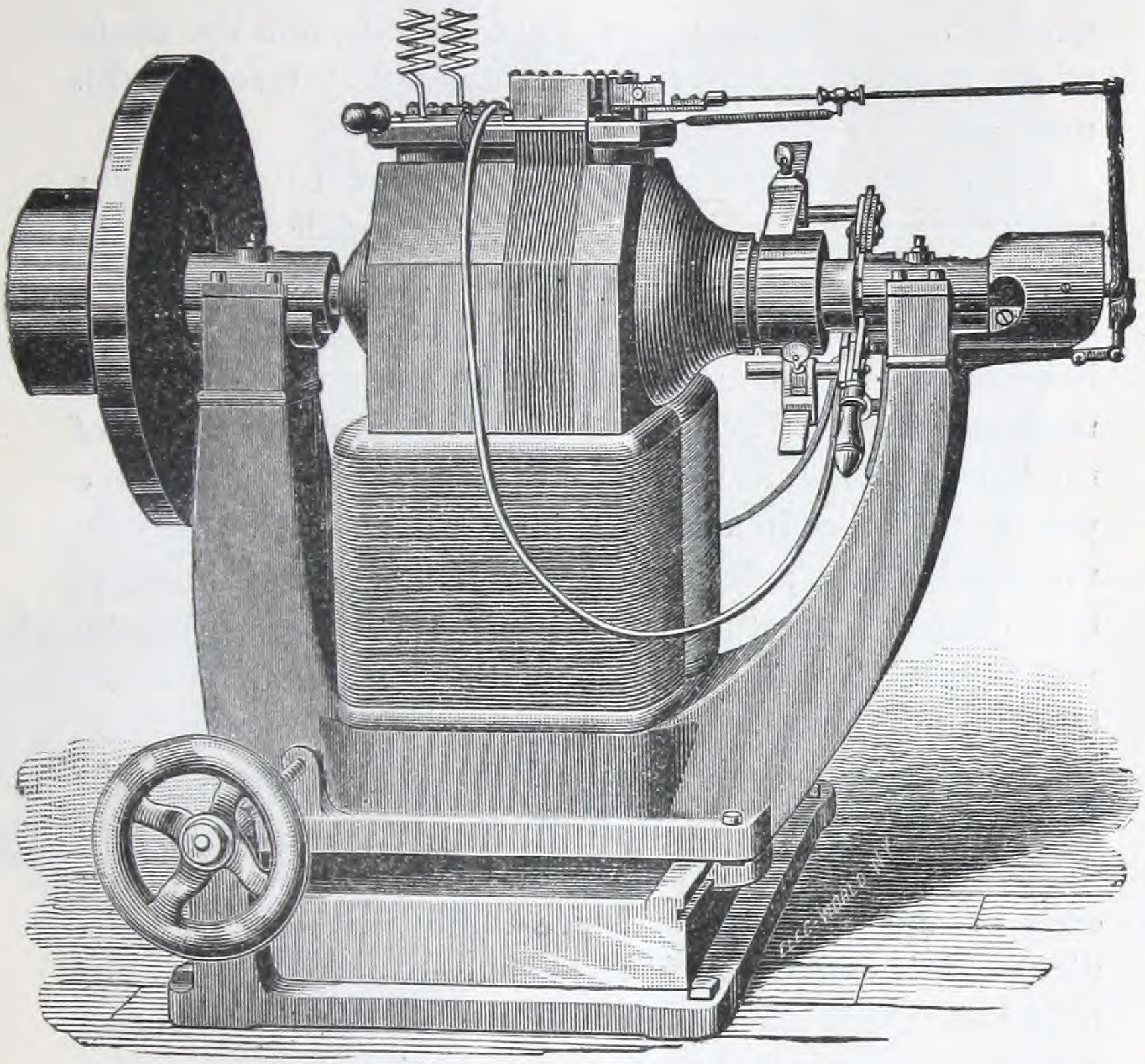
The Eddy Co., while preserving the general excellent ring form of field by use of large round corners, have made the coils straight. They can easily be wound in a lathe, using but one wire, and insulating between the layers. Wires having large differences of potential between them do not cross each other. They can safely be wound for all commercial voltages, and attain at reduced cost, the same high efficiency of the Mather type. The amount of current in the field-magnet coils is therefore very small. The magnets do not get warm.

The watts consumed in charging the magnets of a motor bear no relation to the work done by the armature, and as far as the efficiency of the motor is concerned may be said to be wasted. It is therefore extremely



EDDY 15 H. P. AUTOMATIC ELECTRIC MOTOR.

important to reduce this magnetizing current to a minimum in order to produce an efficient motor. At the same time, as will be shown, high efficiency in a motor requires a *strong* magnetic field.



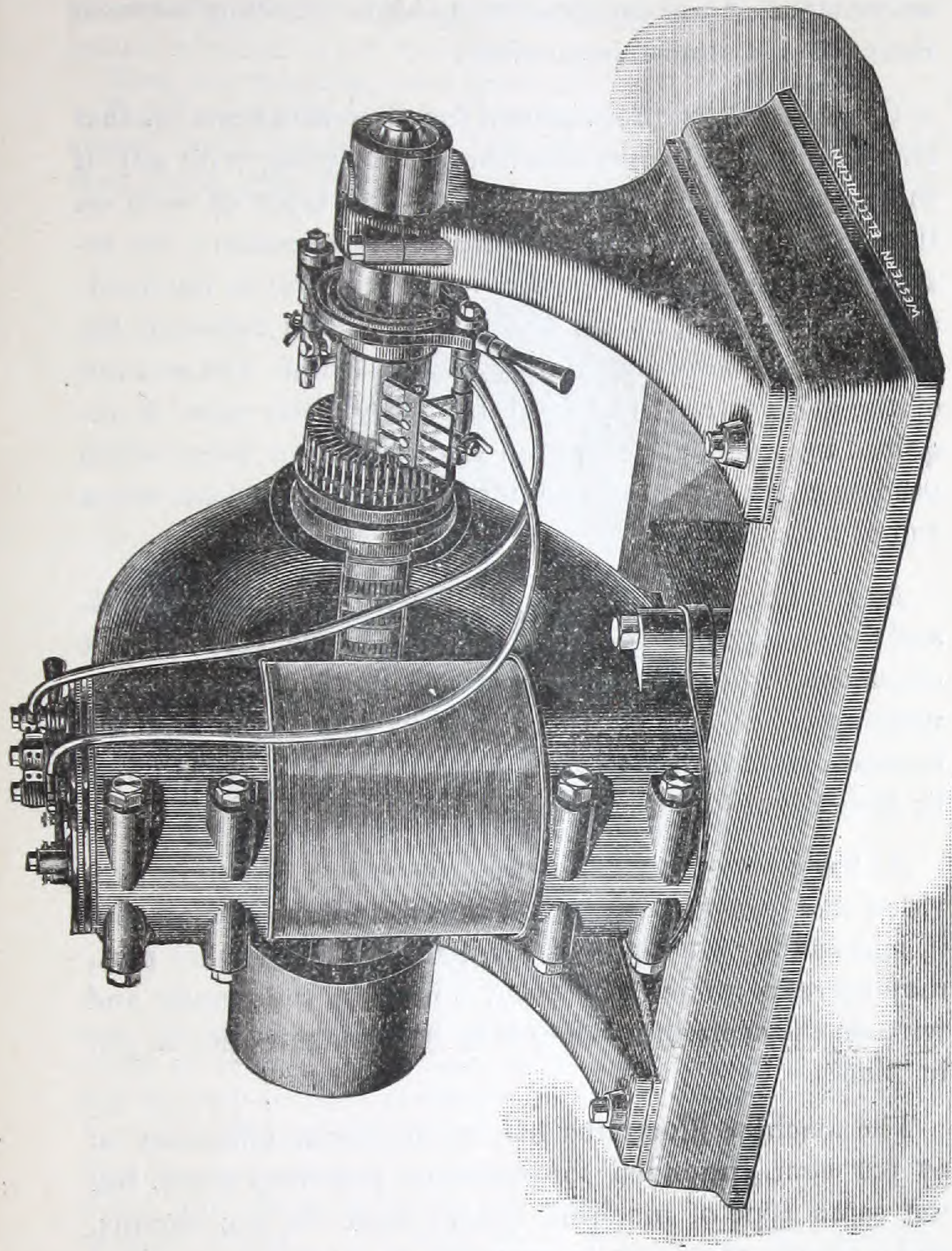
THE EXCELSIOR MOTOR.

Description of the New Jenney Motor. — The accompanying cut illustrates the new motor and dynamo designed and perfected by Chas. D. Jenney, the well known inventor of the Jenney systems of electric lighting. This machine is widely different from those in general use. The armature, field magnet, and the shape of the pole pieces, are the characteristic features of this machine.

It has been the aim of the inventor to produce a magnetic field of enormous strength, which will at the same time be economical to maintain. By studying the direction of the magnetic lines of force about a straight bar magnet, the inventor was led to design the form of magnet shown. The natural direction and curvature of the lines of force, as they pass through the air from one pole to the other in a bar magnet, are well known. In this machine the pole pieces were made to correspond to the natural curvature of the lines of force, thereby reducing the length of the magnetic circuit and its resistance, to minimum.

The magnet core is made of the softest of wrought iron, and is turned back from each end the same diameter to which the pole pieces are bored. On the ends of the pole pieces nearest the observer, perpendicular slots extend out from the core, and by means of bolts they are firmly clamped to the core, thus securing a most perfect magnetic union between the respective parts.

The armature, although of the drum type, is quite different from anything heretofore made. The core is built up of thin iron discs, all of which are securely fastened to the shaft. No wires are wound over the ends of the core, but special heads are provided which



THE NEW JENNEY ELECTRIC MOTOR.

complete the connections at the ends. These heads are so constructed and insulated that short-circuiting between their parts is almost impossible.

One special feature claimed for this armature is, that any wire can be removed without interfering with any of the remaining ones. There is but one layer of wire on the armature, and but one turn to each section; he resistance, therefore, is very low. In addition to the insulation on the wire, an air-space is provided between the convolutions, affording thorough ventilation. On account of the great strength of field, but very little wire is required to produce the desired electro-motive force when used as a dynamo, and counter-electro-motive force when run as a motor.

As the length of the wire on the armature is reduced, and the strength of the field increased, the current that circulates through the armature coils has but little demagnetizing effect, and the variation in the "lead" of the brushes, from nothing to full load, is slight. It may also be added that these machines run without sparking.

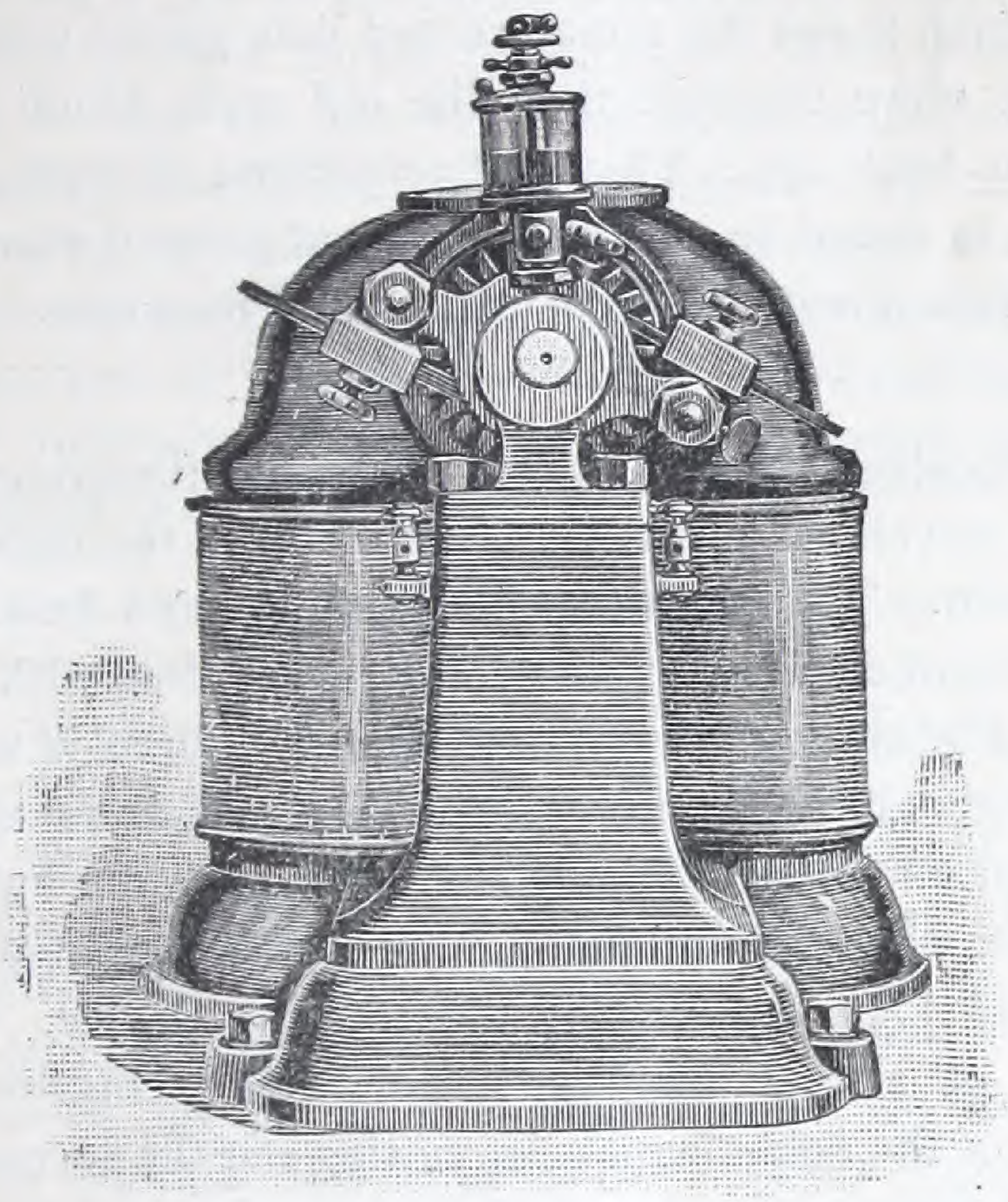
At the ends of the armature, insulating discs are provided that prevent dirt or copper dust from getting into it, and as they are larger in diameter than any other part, they serve as guides to prevent injury to the bands and wire on the armature, when it is being taken out, or put in place.

The machine illustrated has an electrical efficiency of 97 per cent., intended for constant potential work, but the same type of machine is also built for arc circuits, and a simple regulator is provided to maintain constant speed.

For constant potential work, these machines are simply shunt-wound—the self-regulation being so close that compound-winding is not required.

They are manufactured from 1-2 to 50 horse-power.

The Ford & Washburn Electric Motor of Cleveland, is shown in the illustration. The special improvement, which they claim, puts their motor far in advance of many others



and places the use of electricity for lighting within the reach of the smallest plants, is its self-ventilating feature; but the motor itself possesses many points of superiority.

The bed plates and brackets are one complete casting. The magnet yokes are wrought iron fastened to the bed plate, and the pole pieces are separate castings bolted to magnet yokes. The field cores are wound on separate shells, and are interchangeable for all machines of same size. The armature shaft is steel and of extra large size.

The especial feature of their motor, as above stated, is the armature, which is self-ventilating. It draws a current of air from both ends and along the line of shaft and out through the discs, which are separated, and through the winding, with openings to let the air pass out. The rapid rotary motion of the armature sends out the current of air, which keeps the armature and pole pieces cool and therefore more effective than the old style which is so liable to heat up. This self-ventilating feature it is claimed, is found in no other motor at present manufactured. It is adapted to both motors and dynamos.

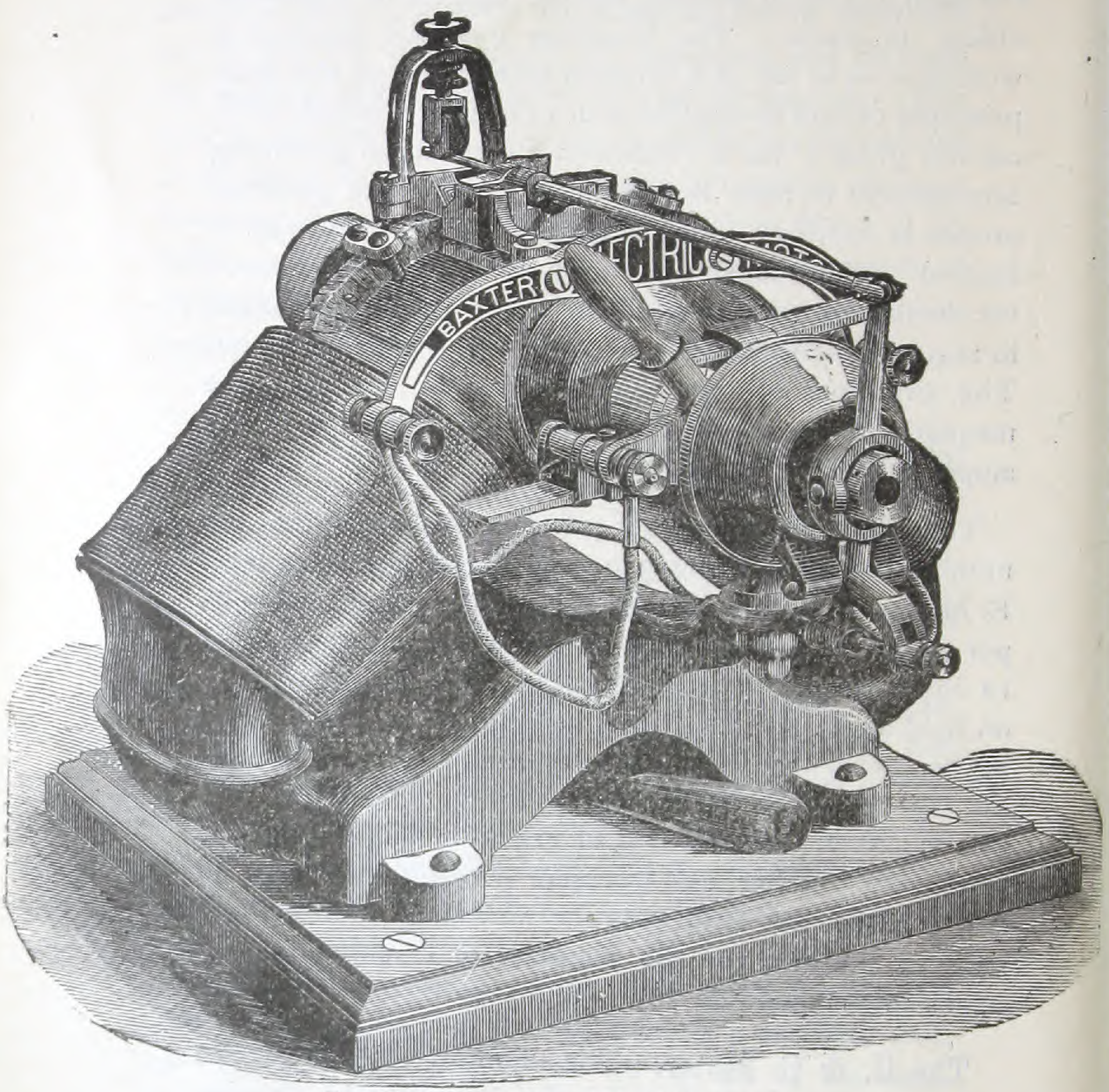
The Excelsior Motor.—The engraving illustrates the arc light circuit or constant current motor of the Excelsior Electric Co. This motor has its armature and field-magnet coils connected in series. As it is supplied with current by a generator whose electro-motive force is varied by an automatic regulator to suit the demands of the motors on its circuit, it would run at a constantly increasing speed, when lightly loaded, were it not regulated and the speed kept uniform by a governing device. This consists of a centrifugal governor which controls the strength of the field-magnets by cutting out the successive layers of wire in the coils as the load decreases, and cutting them in when it increases.

The two main bearings of the motor-shaft and the ball and socket bearings of the governor are provided with oil chambers, from which the oil is led to the wearing surfaces by means of felt strips. (See motor, page 53.)

The Constant Current Baxter Motor.—There is no difference in design between the Constant Current and Constant Potential Motors, but the method of regulation differs in each. The Constant Potential machine is wound so as to run at a constant speed; but as the same principal cannot be applied with a Constant Current, without too great a loss in efficiency, a mechanical governing arrangement is used in the latter type. The governor proper is carried on the outer end of the shaft, and is located within the shield shown in front of the motor; the device, by which the action of the governor is made to regulate the speed, is located on top of the pole-plate. The principal of regulation consists in changing the magnetic intensity of the field by a variation of the ampère turns in the magnetic-coils.

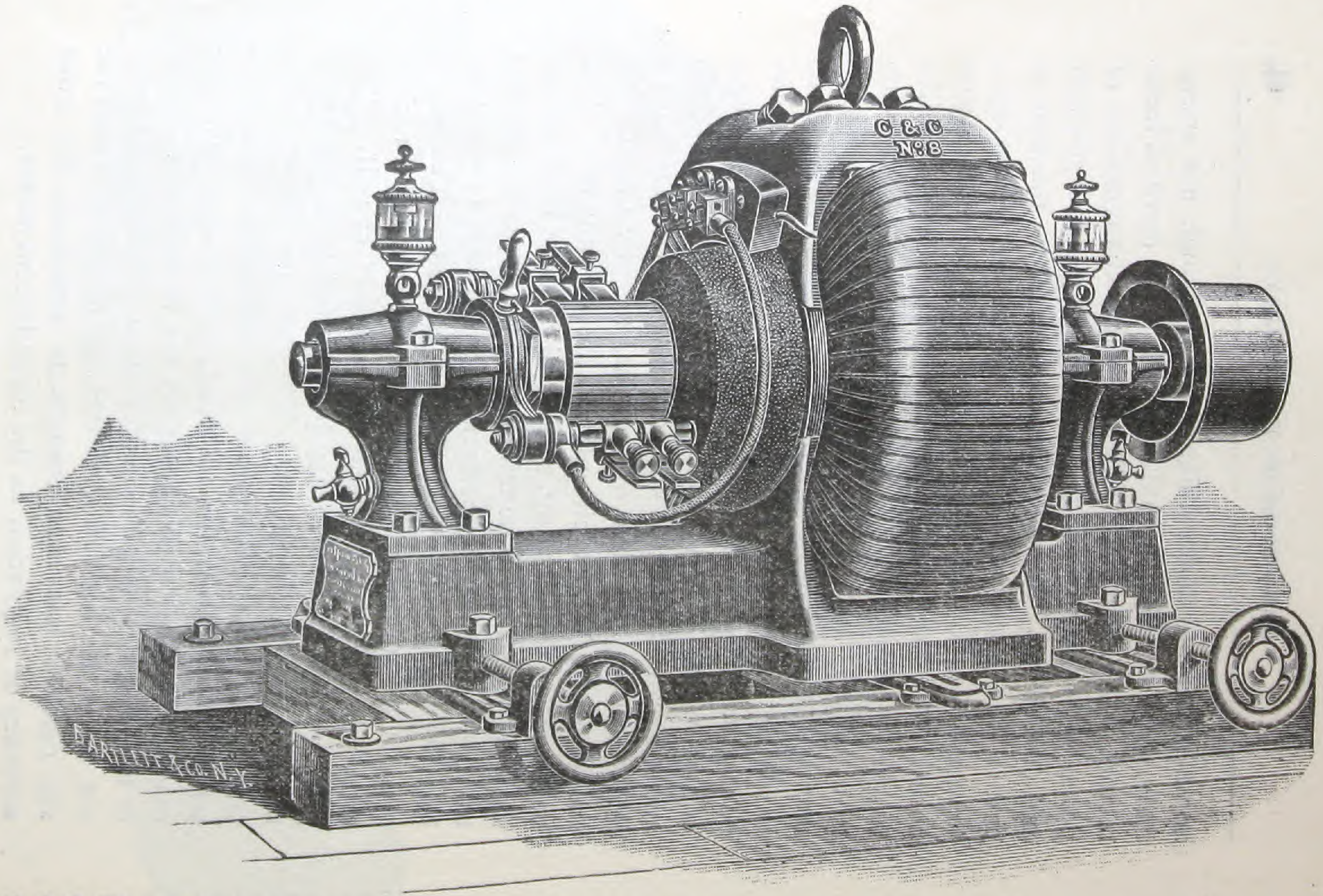
There are two layers of wire on tne armature, the number of turns being 320; as this sets up a counter E. M. F. of about 750 volts, it is at the rate of 2.28 volts per turn. The weight of wire on the armature is about 12 lbs.; weight of iron about 75 lbs.; weight of wire on field about 160 lbs.; iron in field, 1,100 lbs. These figures show that a very small amount of wire is used, but that otherwise the machines are very massive. On this account, the re-action of armature on the field is practically nothing, and therefore the brushes require no lead; hence the load may be varied at will without causing sparking, as the diameter of commutation remains unchanged.

The C. & C. Motor.—The adjoining cut represents a 3 horse-power C. & C. motor for incandescent circuits, and is the standard type of machine made by this company, in all sizes above 1 horse-power. The motors of 1



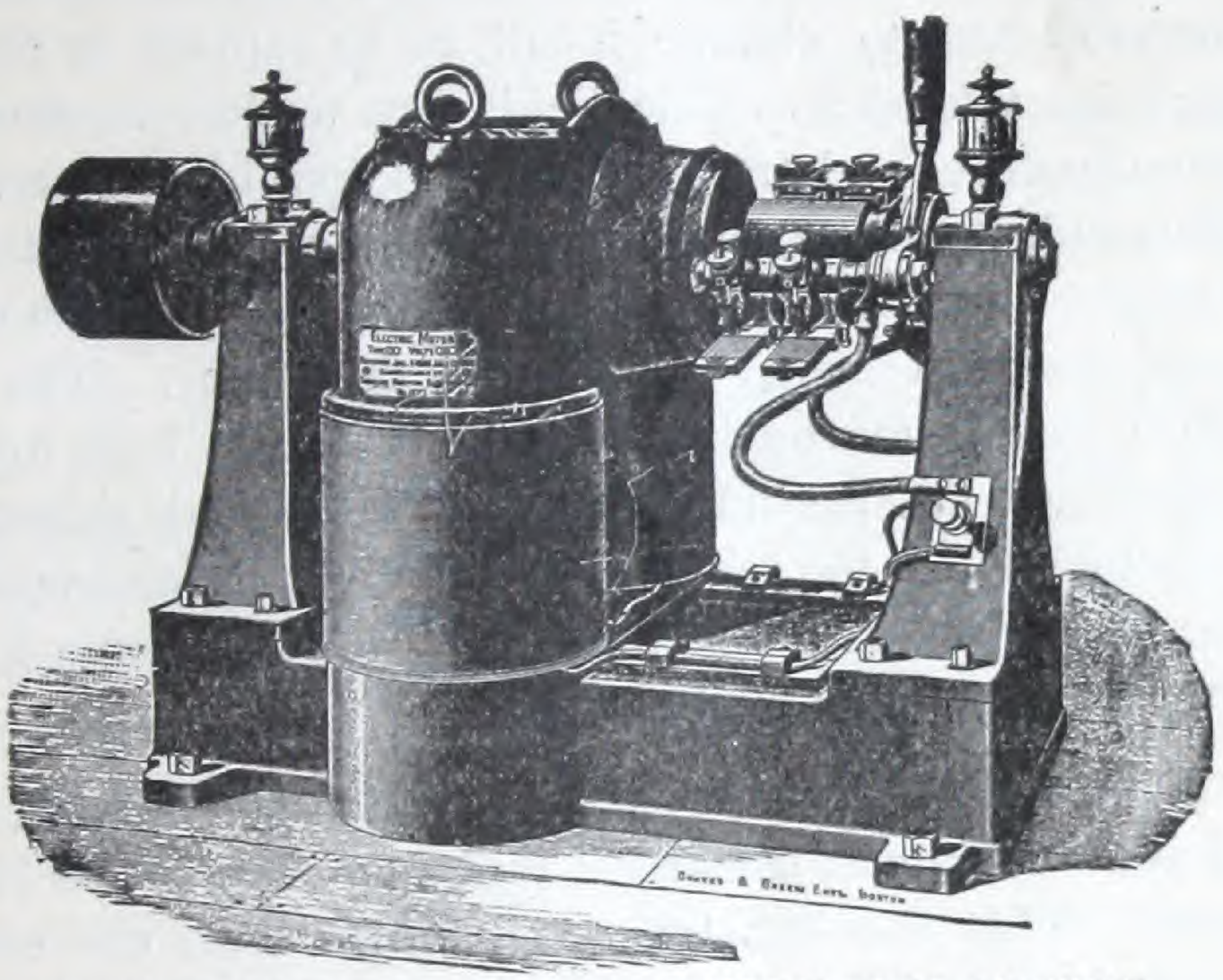
BAXTER ELECTRIC MOTOR.

horse-power and under differ slightly, though not essentially, from the form here delineated. The merit of these motors lies in their high efficiency, interchangeability of parts, self-lining bearings and in their general strength and durability. The lower pole-piece of the machine is cast in one piece with the bed, the upper one being a separate block. To these are bolted the field-magnet cores. The cores are of forged wrought-iron shaped like segments of a circle. This form of magnet-construction gives the shortest possible magnetic circuit, thereby reducing the quantity of iron used and the power required to excite the magnets. For this reason, it is a very compact machine, requiring the least space for the same power of any made. An improved Siemens' winding is used, and the armature and commutator are divided into more than the usual number of sections, thereby diminishing the danger of short circuits in the commutator. The bearings are self-aligning, so that they cannot bind, allowing the armature to be taken out and replaced without trouble. The bearing parts are of hard cast bronze; an improved adjustable feed oil-cup is used. The brush-holders are supported on brass rods attached to a rocker-arm, which may be tightened or loosened at will. The pressure of the brushes may be adjusted by the slightest movement of a single nut. The machine shown in the cut makes 1,650 revolutions per minute and regulates within 3 per cent. for all load variations. The arc machines made by this company are in form very similar to the incandescent, the main feature of difference apparent being the regulating device, by means of which the arc machine has been brought to practically the same accuracy of regulation as the incandescent motor.



C. & C. ELECTRIC MOTOR, 2 H. P., FOR INCANDESCENT CIRCUITS (CONSTANT POTENTIAL.)

The Thomson-Houston Stationary Motor. — The general design of the Thomson-Houston motor is such as to render it compact, convenient in manipulation and neat and attractive in appearance, while at the same time the electrical proportioning is such as to secure the highest efficiency in conversion of electrical into mechanical energy. The 15 horse-power motor shows an average commercial efficiency when fully loaded of 91 per cent. This high efficiency is obtained by paying careful



THOMSON-HOUSTON STATIONARY MOTOR.

attention to the electric and magnetic proportioning of the motor. The magnetic circuit is very short and of ample section, and therefore of low resistance, and the magnetic poles are so formed as to convey the magnetism into the armature with the least possible loss. As will be noted in the engraving, the poles of the field-magnets, the bodies or cores of which are round in

section, project upward enclosing the armature. The armature is nearly square in longitudinal section and relatively large in diameter. This gives a high peripheral velocity and a rapid cutting of the lines of force. In consequence of this construction, also, the armature is capable of exerting a powerful rotative force or torque, such as is demanded in tram-cars, etc. The armature being short, avoids the use of a long and consequently less rigid shaft. The coils of the motor-magnets are wound on bobbins which are slipped over the core; it is therefore easy to change a coil or to replace it for any purpose whatever. The fields are wound in shunt to the armature, and are relatively of very high resistance. This reduces the amount of electrical energy required to energize the field-magnets to a very small fraction of the total electrical energy absorbed by the motor. The armature core is thoroughly well built in the best manner known to the art and is a very solid and substantial structure. At the same time the perfect lamination of the core reduces the loss by Foucault currents to the smallest possible amount.

The winding on the armature, which is a modification of the well-known Siemens' type, is of very low resistance. This low resistance, combined with the careful construction of the armature-core, renders it possible to greatly overload the armature without any heating effects being noticed. In fact, when running at normal load, the motor-armature runs practically cold.

The copper wire on the armature is held in place by means of bands which are made of such strength that it is impossible for them to yield from the centrifugal force, even when the motors are run at abonrmal speed.

The Thomson-Houston W. P. Railway Motor.—*One of the most interesting exhibits at the Pittsburg Street Railway Convention was a new slow-speed railway motor of the Thomson-Houston company, of which the accompanying illustration gives an excellent idea. It had been in process of evolution for six months or more and has been worked up under the careful superintendence of Mr. Walter Knight. The new machine embodies some decidedly novel features and its excellent performance on the special car equipped with it was very favorably commented upon. It is known to the trade as the W. P. motor, which being interpreted means water-proof, and it well deserves the name, because of the particularly complete iron-clad character of the field magnets.

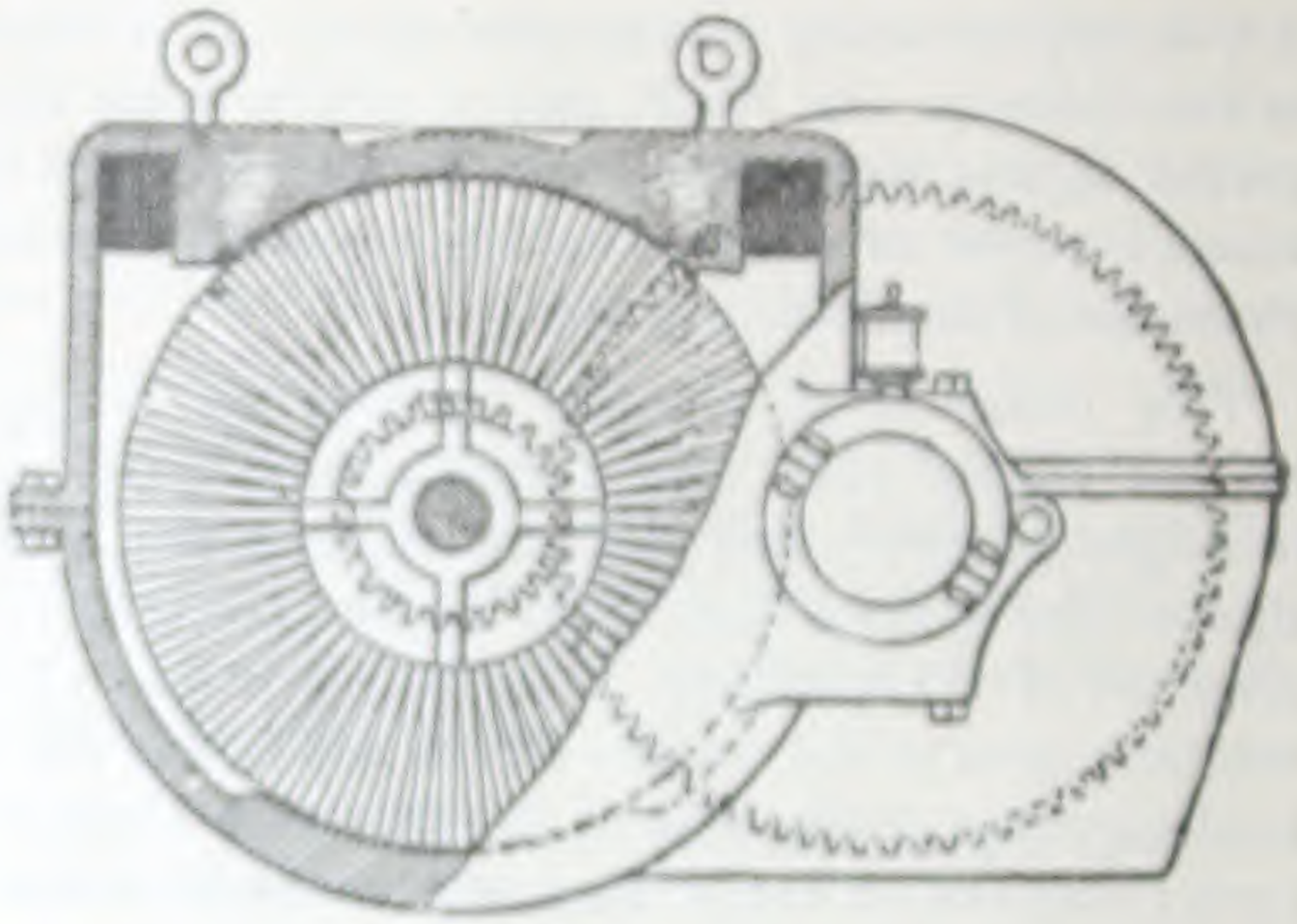
This motor is a two-pole machine so arranged on the theory that the comparatively slight gain in weight efficiency that could be obtained with a multipolar type is more than offset by the increased complication of the windings. The only portions of the machine open to the outside air are exposed at the two oval openings at the ends of the armature shaft, and even these can be easily fitted with covers should such a course prove desirable. The whole magnetic circuit is composed of two castings bolted together and free to swing apart by a hinge allowing ready access to the armature.

The accompanying cut gives an excellent idea of the internal arrangements. The armature itself is very nearly twenty inches in diameter, a very powerful Pacinotti-ring nearly six inches on the face and of

*Electrical World.

about the same depth. It is wound with comparatively coarse wire in sixty-four sections, with fourteen turns to the section. Each coil is tightly placed in the space between two of the projecting teeth, and about the interior space these separate coils are closely packed, leaving only sufficient room for the four-armed driving spider.

As will be seen, the armature takes up most of the full height of the machine, the pole pieces being but



trifling projections and the requisite cross-section of iron being obtained by extending the poles to form a closely fitting box that appears in the exterior view. An unusual feature is the use of but a single magnetizing coil wound not directly about the upper pole piece but on the casting immediately surrounding it. The lower pole is but slightly raised and both pole pieces are of the greatest extent permissible with the dimen-

sions of the machine. The use of a single magnetizing coil produces naturally an unbalanced field and a strong upward pull on the armature tending to relieve the pressure on the bearings. The iron-clad form, however, tends to distribute the lines of force so as to avoid the sparking and change of lead that might otherwise have to be feared. The single coil is wound with quite coarse wire and its position insures the maximum magnetic effect from the current.

The speed of the new motor is about the same as that of the older S. R. G. form, and its general working efficiency is somewhat better, owing not so much to a greater maximum of efficiency as to a better working curve—at both heavy and light loads. The brush holders are shown in the cut, and the slots in which they fit render their position evident. The brushes are of the ordinary carbon description and are readily accessible through the opening at the end of the shaft.

ELECTRIC RAILWAYS.

The first electric railway was constructed and exhibited by Dr. Siemens, at Berlin, in 1879.

The first electric railway in the United States was constructed and put in operation by Thomas A. Edison, at Menlo Park, N. J., in 1880.

There are a number of systems in operation at the present time, such as the Daft, Van Depoele, Julien, Bentley–Knight, Sprague, Thomson–Houston and Edco, —all of them make claims of superiority, and I have no doubt but that they all have good points. The most successful systems seem to be the overhead system and the storage-battery system.

The overhead system, as used in the Sprague, Thomson–Houston, Van Depoele, etc., consist of attaching electric motors to street-railway cars, and of operating electrically equipped cars by means of conducts suspended over the track.

The electric circuit in the general systems, as in the Sprague Railway system, consists of two parts—the overhead and the ground circuits, each being of compound character.

In distributing the current, the rails are grounded and form one side of the circuit. If they have a good electrical connection from one to the other through fish-plates already in position, they form a path of very low resistance. Where such connections are poor, the rails are reinforced by a continuous conductor running the entire length of the line. The other part of the circuit consists

partly of a hard-drawn silicon bronze contact-wire of small size, but great tensile strength, which is suspended 17 to 18 feet above the track.

This contact-wire is termed the working-conductor, and is carried over the centre of the track, at the height named, on insulators supported by span-wires running across from pole to pole and provided with additional insulators at their ends, or else by brackets which extend from poles placed on the side or centre of the street.

The size of this wire is independent of the number of cars operated, or the distance over which the line extends.

The curves are formed of a series of short chords, which approximate the central line of curvature.

The whole structure is very light-looking, and it seems wonderful that it can be made the medium for the transmission of sufficient electrical power to propel any number of cars over any length of track.

The main current, however, is not carried by this small wire, but is carried by a main wire running parallel to the working-conductor and connected to it at intervals of every few hundred feet. This main conductor which can be carried upon poles at the side of the street in the same manner as telegraph wires, or else buried in a subway, underground, is itself supplied at different points by feeders, which come from the main supply at the central station. Without the use of these feeders, which also can be reinforced if necessary, the size and cost of the overhead conductors would be very largely increased.

By means of these feeders, and by use of automatic cut-outs for dividing the line into sections, which are placed at the junctions of the feeders and main conductor,

all danger of an accident on any portion of the line disabling the operation of the remainder of the road, is avoided. This is a matter of great importance, and its value cannot be too highly estimated.

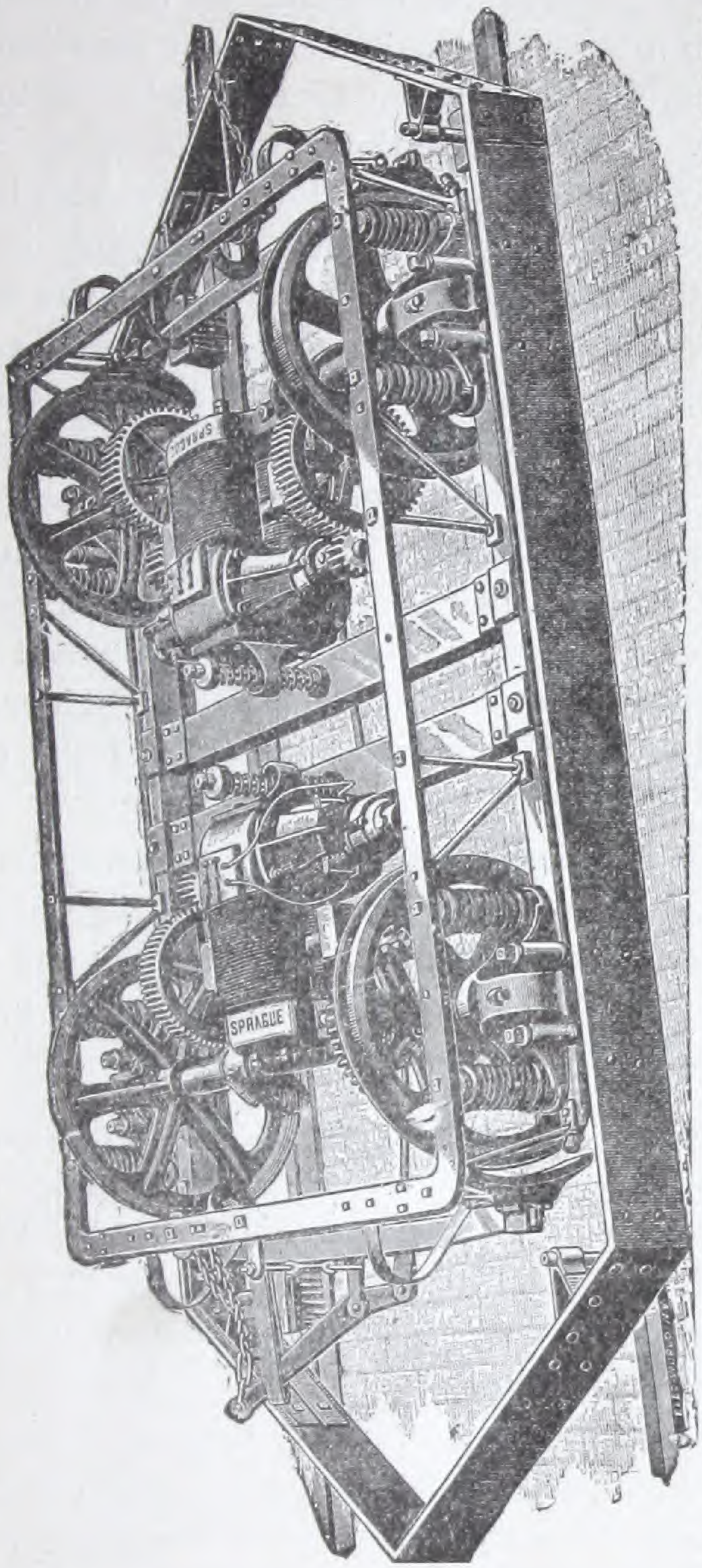
By means of this system, also, as the greater portion of the current is carried upon the main conductor and only a small portion on the working-conductor over the middle of the street, there is no change in the size of the working-conductor, and consequently no stoppage of travel required, with an increase in number of cars run or an extension of the line.

The current is taken from this working-conductor by a small structure on top of the car. This consists of a light trolley-pole supported upon a stout spring, so that it can move in every direction, and having at its upper end a grooved wheel, making a running flexible contact on the under side of the working-conductor. The flexibility of this arrangement is very great, it being able to follow with facility variations of the trolley-wire four or five feet in either a horizontal direction, or more than twelve feet in a vertical direction. By this means a constant contact is made by the trolley-wheel at different rates of speed or around curves, and for different heights of the trolley-wire.

It is impossible (working underneath) to pull the trolley-wire down; and if off the line, the trolley can be replaced quickly and easily, even in the darkest night.

By the use of this underneath contact, not only are there no complicated switches on the overhead conductors, but all changing of contact is avoided when passing the turnouts.

In order to secure the necessary track adhesion by means of independent driving, and to permit the entire



INDEPENDENT TRUCK, EQUIPPED WITH SPRAGUE IMPROVED ELECTRIC MOTORS.

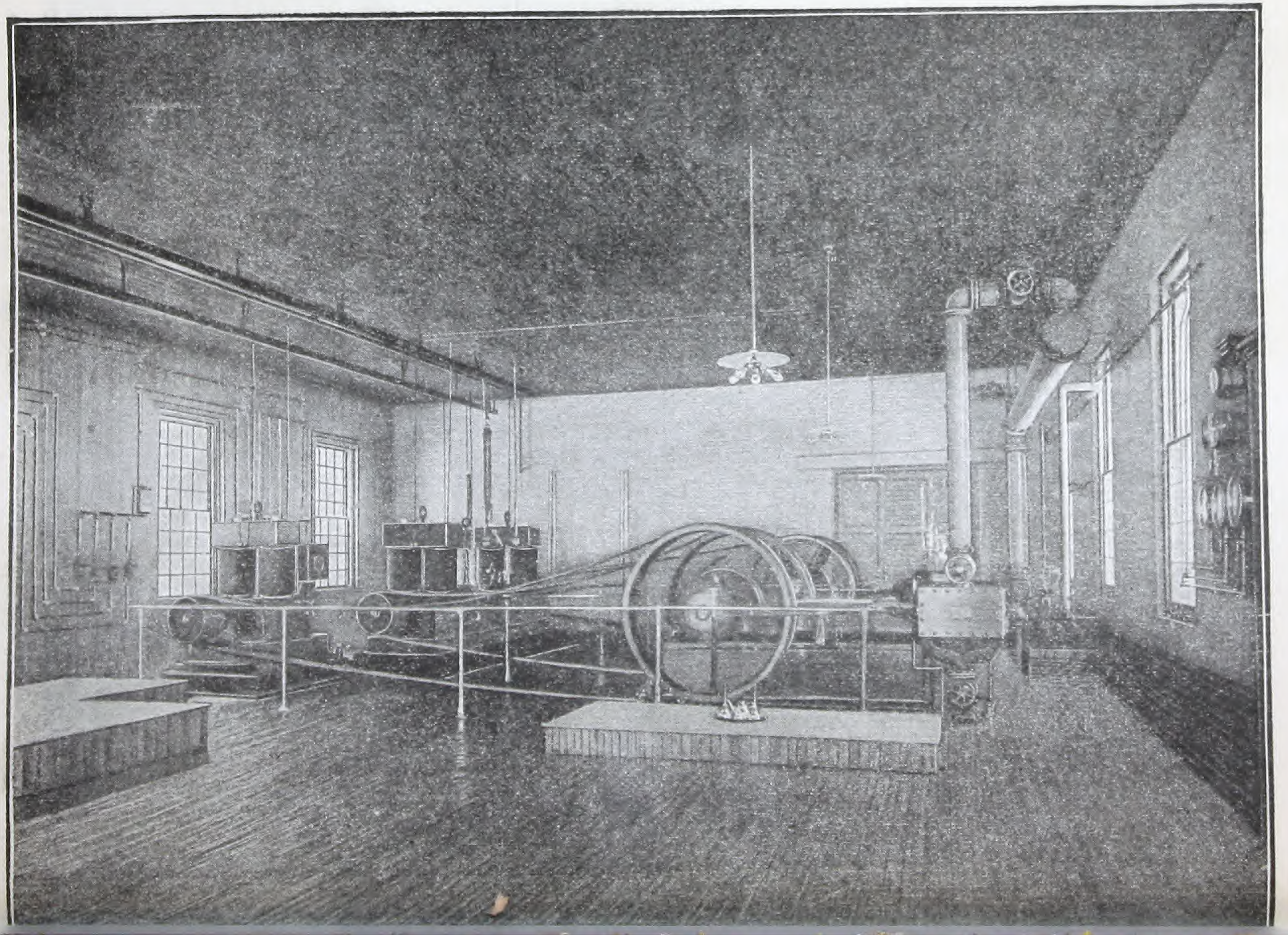
weight of the car and its contents to be available for traction, two motors are used on each car (see illustration of Sprague railway truck), one for each axle, with independent driving. At the same time both motors are capable of perfectly simultaneous control by a switch placed at either end of the car—this switch controlling both the speed and the direction of movement of the motors. These motors are of 7 1-2 or 15 H. P. normal capacity each, making an aggregate of 15 or 30 H. P. on each car.

Both motors are simultaneously governed by a single switch from either platform which throws the winding of the motor-field into different electrical combinations, thus altering the current, maintaining practically a constant field and thereby varying the power and speed of the motor, without the use of any wasteful resistance. By this method there is no loss of power, and the control over the car is perfect.

Each car and the main station are fully protected from any possible damage from lightning by lightning-arresters, which are perfectly automatic in their action, and which remove all possibility of danger of accident to the cars or generating apparatus from this cause.

The Scranton Power Station. — The accompanying engraving gives a very good view of the interior of the electric power station of the Scranton Peoples' Electric Railway. The steam plant includes two 125 H. P. Armington & Sims' engines, and the electrical plant includes three 40,000 watt dynamos.

The interior of the station is finely fitted up. The floor and ceiling are hard wood, and handsomely finished. All connections to the dynamos are of burnished copper rods. All steam-piping is covered with magnesia sec-

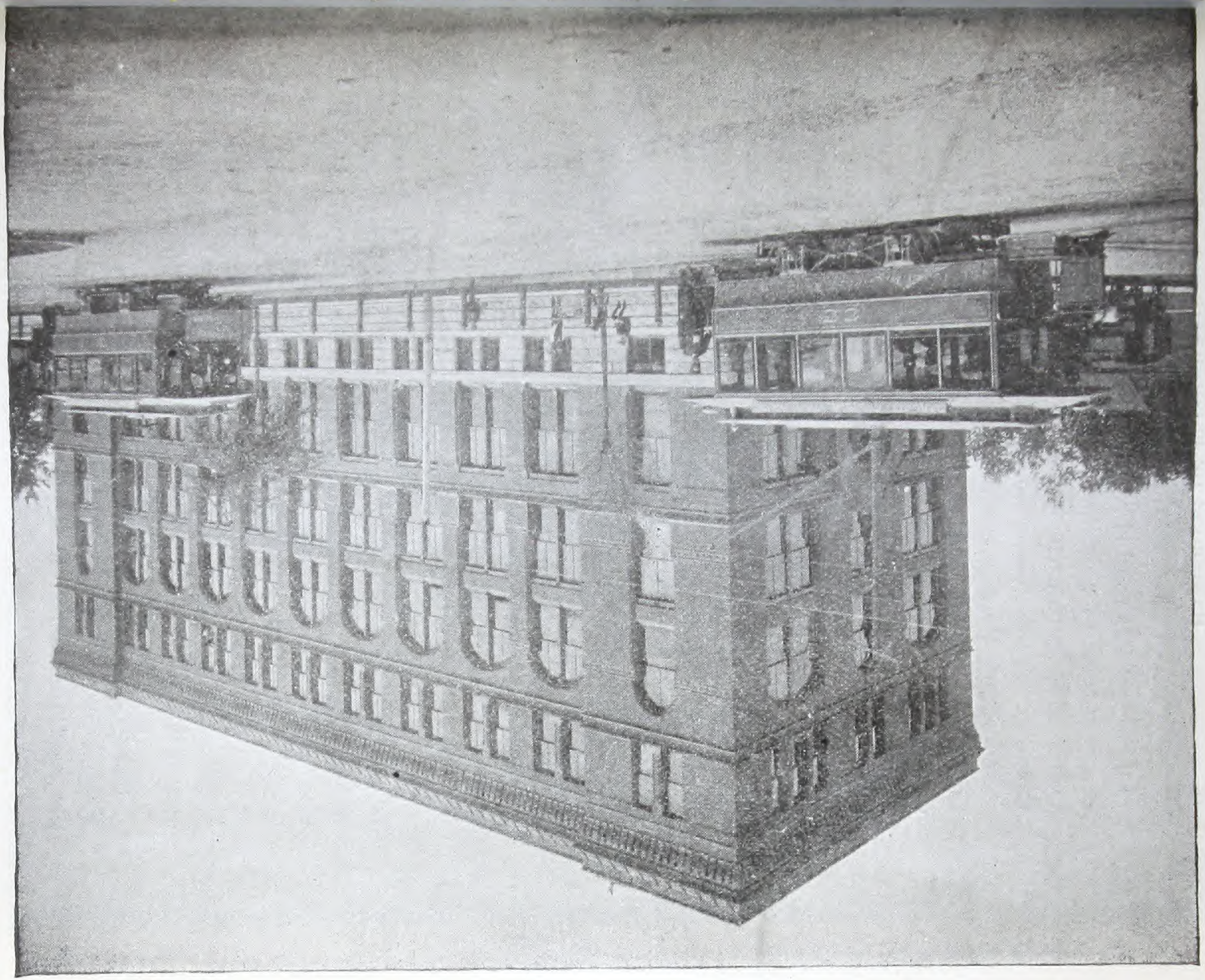


tional covering. All the instruments, gauges, etc., are mounted on polished slates of mahogany; in short, this is a model electric-power station in every way.

The road, which operates 20 Sprague electric cars, extends over a number of very steep and severe grades, and is one which requires great variations of power. In spite of the amount of power required, it is said of this station that it costs less to provide fuel to run the engines and generate the electric current than it would cost to keep one horse.

The reason of this is that the station is right near a pile of culm or coal screenings, so that fuel can be purchased at a very low rate. This is one place where the use of electricity for driving street cars is especially advantageous, and with the many cities in coal regions and near unused water powers, the use of electricity would be found extremely advantageous.

The Topeka Rapid Transit Railway—(the longest electric railway in the world.) While it is a fact that the West End Street Railway Company of Boston (combining its two systems) is operating more miles of electric railway than any company in the world, the electric railway at Topeka is the longest line which has yet been built using one system, and receiving its current from one central station. The roads which have heretofore been built by the Thomson-Houston company in the West, have been constructed in the best possible manner, and are successful in every particular, but the road in question is by far the longest, and no pains have been spared to make it a model road in every respect. Its operation since its starting—the first of April—has proved this to be a fact. The construction work was begun about Jan. 1, and finished about the first of April. When it is called



to mind that this road is 14 miles in length and has a total length of track of 20 miles, and that the utmost care was exercised in its construction, even to the smallest details, it will be seen that good time was made.

In building the line the overhead method of construction has been employed, the rails serving for the return current.

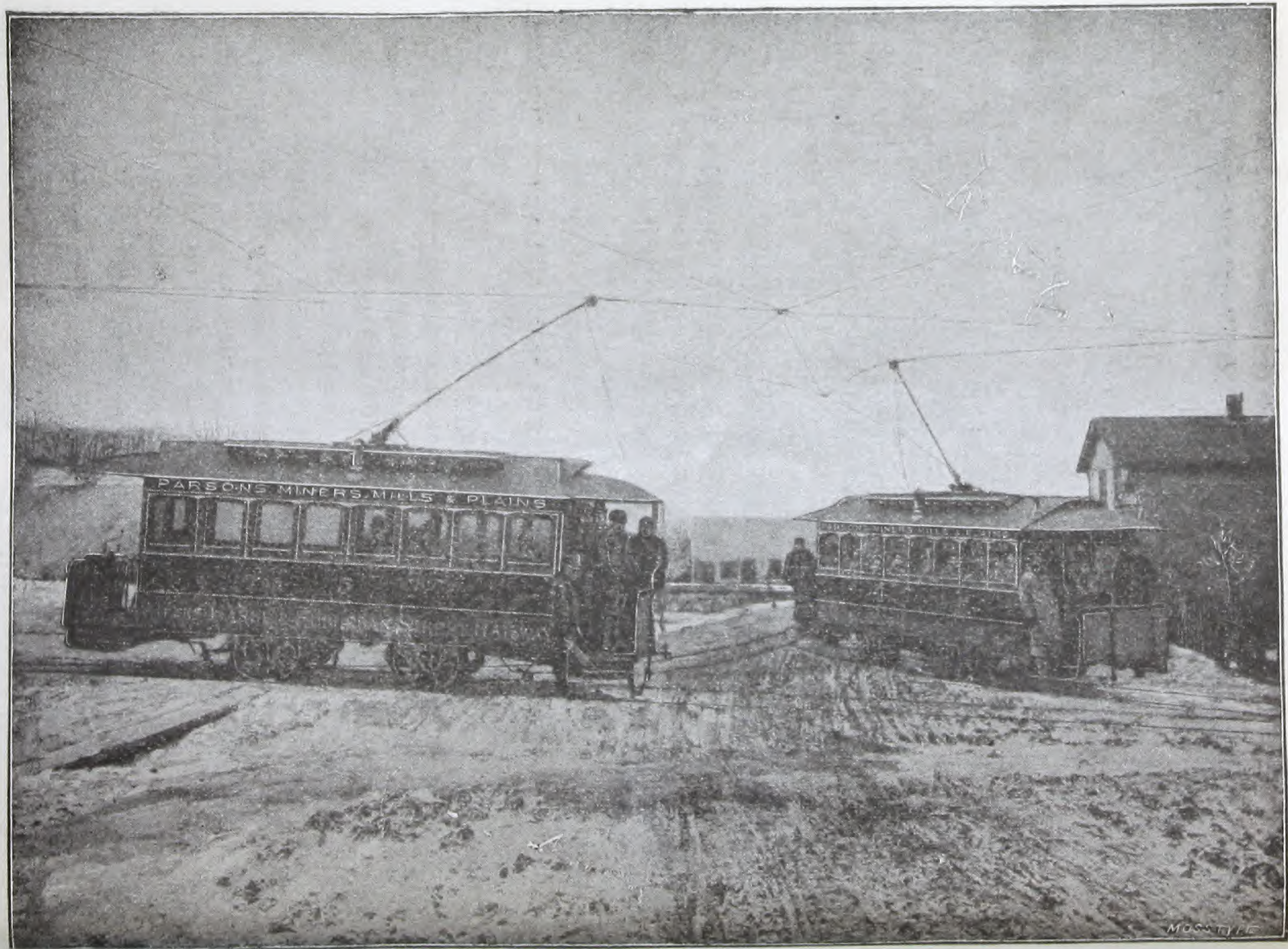
The cars, twelve in number, are each equipped with two 10 horse-power motors.

Since the road has been in operation it has been visited by many prominent railway men, and it has been the generally expressed opinion that the road in construction and operation is a model electric railway, and reflects the utmost credit upon the Thomson-Houston Electric Company.

The Sprague Electric Railway at Wilkesbarre, Penn.—The accompanying engraving is from a photograph giving a view of two Sprague electric cars on the Wilkesbarre and Suburban Railway, at Wilkesbarre, Penn. This road has been running for about nine months on the Sprague electric system.

The view gives a very good idea of the Sprague method of overhead wiring for a Y, and shows the lightness and unobtrusiveness of the Sprague overhead system. In this system, the entire current to operate the cars on the line is not carried over the centre of the street, but partly at the centre and partly at the side, thus enabling the wires over the centre of the street to be of the lightest description possible.

The Thomson-Houston Electric Railroad at Lynn, Mass.—Starting in one of the busiest portions of Lynn, the road passes out through Union street on an easy


PARSONS MINERS MILLS & PLAINS

ascent, and a sharp curve brings it to Ireson street, where it encounters an increased grade, combined with a reverse curve, on Essex street. The road then goes through Rockaway street, where there occurs one of the steepest grades on the road. (See engraving). From here the road lies through Hollingsworth and Herbert streets, with sharp curves and slight grades. Passing into High Rock street, a grade of nearly twelve per cent. is met, on which occurs one of the sharpest curves on the entire line. From Rogers avenue through Essex and Market streets the road is comparatively level to the starting point.

The line is at present operated as a belt line, and although the direction of the cars is down the steep grade, it can be easily surmounted in the other direction, as has been shown on several occasions when the trolley has been reversed at the bottom of High Rock-street hill, which the car ascended with perfect ease.

The Sprague Electric Railway at Richmond, Va.—The method of jumping fire hose on the track is very simple, and the view showing it was taken from a photograph. A small metallic bridge is laid on the track over the hose, and the car runs over this without interfering with the operation of the fire department. Of course such a simple device as this would be impossible upon a cable road or an electrical road using a conduit. The bridge, when not in use, is carried under the seats of the cars.

The Edco Car, illustrated on page 82, is manufactured by the Electro-Dynamic Co. of Philadelphia.

The car motors are known as the "Edco," and as now made are rated at 10 horse-power each, but are capable,

MARKET ST. CENTRAL SQ. & ROCKAWAY ST.
HIGH ROCK

for brief periods of time, of exerting considerably greater power.

The electric current is furnished by accumulators or storage batteries furnished by the Electrical Accumulator Co. of New York. These cells are stored when in use under the seats of the car.

The batteries, when fully charged, are capable of propelling an ordinary car loaded with 50 passengers, over a level road, at the rate of 9 or 10 miles an hour, for about 6 hours, allowing for the average car stops and lay-offs at the terminals. The car would, therefore, require one change of batteries for a day's run of 12 hours. The weight of a 16-foot car, equipped with two motors, is about 3 1-2 tons, without passengers. The batteries supply electric light for inside lamps and head-lights, and power for signal bells and alarm gongs.

An accumulator car can ascend steeper grades, and go at a faster rate of speed, either on grades or on a level road, than is possible with horses, but always, of course, with a correspondingly greater expenditure of energy. In case of a single excessive grade on an otherwise level road, it may be advisable, on the score of economy, not to provide power for each car sufficient for surmounting such grade, but to use an auxiliary motor car, or tow-horse, as is now customary. Accumulators, like horses, are, for brief periods of time, capable of doing many times their safe or normal amount of work; but also like horses, any excessive amount of work which they are called upon to do, can only be done at the cost of shortening their life.

N.O.PASS.RY.CO.
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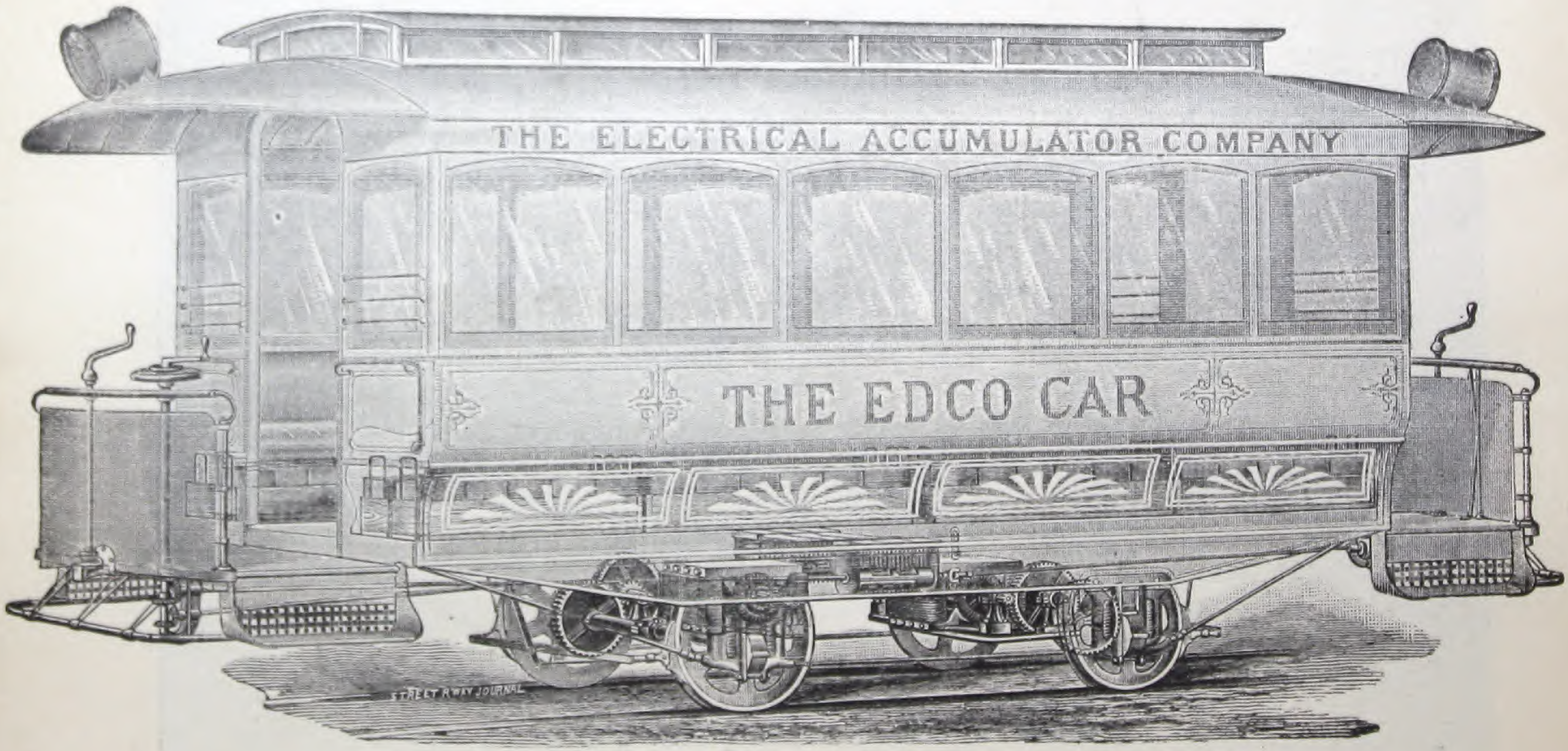

THE ELECTRICAL ACCUMULATOR COMPANY
THE EDCO CAR
STREET RWAY JOURNAL

ELECTRIC WELDING.

Electric Welding Machine.—The machine shown in the engraving is for welding 3-inch extra heavy iron and steel pipe.

The process of Electric Welding and Working of Metals, as invented by Professor Elihu Thomson, has already been so far developed as to produce the most satisfactory results. Welding machines capable of uniting various sections of metals have been placed upon the market, giving manufacturers ample proof of their efficiency and economy, and already becoming a part of the necessary machinery required in the various industries with which they are associated.

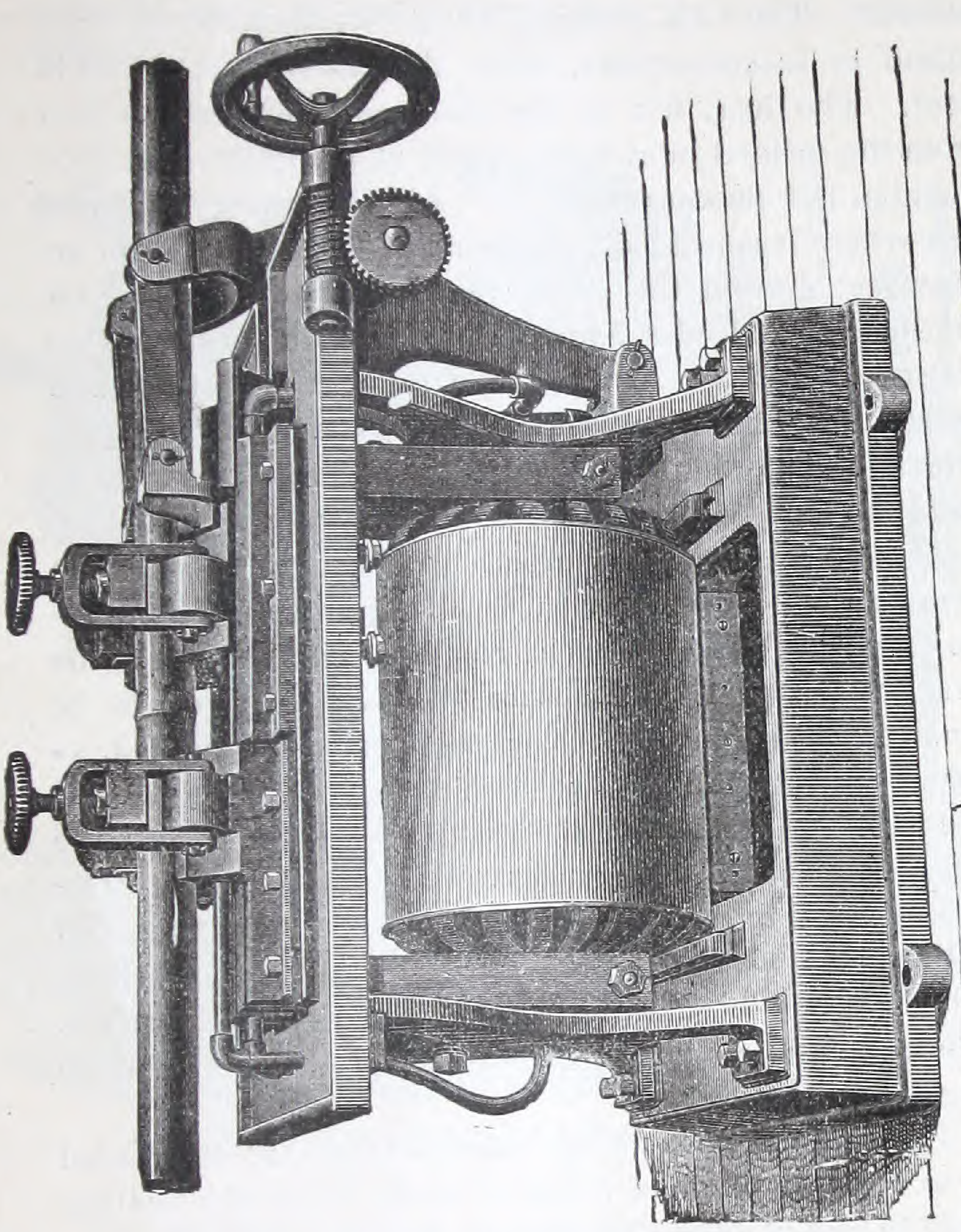
The principle involved in this new art is that of causing currents of electricity to pass through the abutting ends of the pieces of metal which are to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time mechanical pressure is applied to force the parts together. As the current heats the metal at the junction to the welding temperature, the pressure follows up the softening surface until a complete union or weld is effected, and as the heat is first developed in the interior of the parts to be welded, the interior of the joint is as efficiently united as the visible exterior. With such a method and apparatus, it is found possible to accomplish not only the common kinds of welding of iron and steel, but also of metals which have heretofore resisted attempts at welding, and have had to be brazed or soldered.

Pieces of such metals and alloys as wrought iron, silver, copper, brass, lead, tin, zinc, bronze, German silver, platinum, gold, aluminium and even cast iron, are not only welded to each other, but different metals can be welded one to another in many combinations, extending the applications of the process to the attainment of results heretofore impossible in metal-working; while the tensile strength of the welds, as shown by mechanical tests under the direction of the U. S. Ordnance Department, are all that can be desired. Solid iron or steel bars three inches thick are welded perfectly. The time consumed in making the weld of this size is from 100 to 120 seconds.

The machines built by the Thomson Electric Welding Company are generators of electricity, so constructed as to produce in the most economical manner the low-pressure currents essential for welding and for similar work. They are of sizes and types suited to the kind and section of the metal to be worked.

The dynamos are built to take power from any source, and the welding machines connected by wires to operate wherever it may be convenient to locate them.

The result of an examination made by Prof. A. E. Dolbear, of Tufts University, was presented in the form of an exhaustive report from which the following extract is made: "This method is scientifically perfect, as the mechanism to utilize it is so simple that there appears no likelihood of any change being made that shall much increase its efficiency. The heat developed in the welding circuit is proportional to the square of the current strength, not proportional to the tension of the current there. The heat in such a circuit is developed chiefly at the

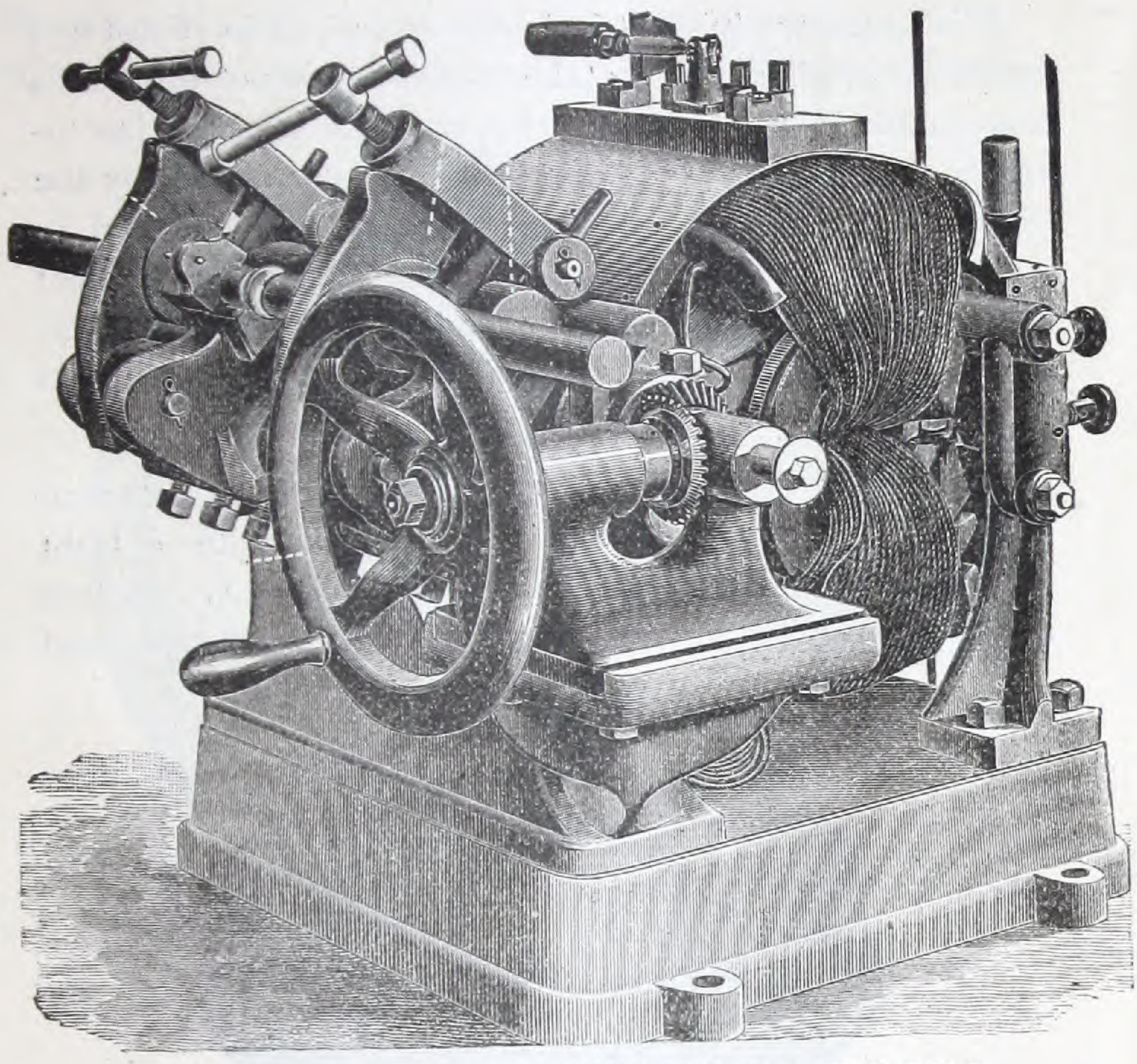


ELECTRIC WELDING MACHINE FOR HEAVY WORK.

place where the electrical resistance is greatest, and in the welding circuit will always be at the junctions to be welded. The two abutting ends, therefore, are at once raised to incandescence, while the rest of the circuit is cool. The heat felt at the distance of an inch or two from the welded joint is the result of common heat conduction, not electrical heating. All the energy is spent just where it is needed. It is one of the properties of an electrical current that it moves in the paths of the least resistance, and the hotter a metal is the greater is its resistance. When, therefore, a current is sent through junctions to be thus welded, the parts of the sections which are more highly heated than the adjacent parts, force the current into the cooler parts, where it is needed, until there is a uniform temperature throughout the whole area—an important point in a welding process. The external part of the welding circuit is so contrived as to be practically a pair of clamps into which the pieces to be welded may be fastened close to the ends to be joined, so that when these ends are in contact an electric ring circuit is completed, consisting of the part included within the primary coils, the clamps and metals to be welded. The energy spent in this circuit is most easily regulated, and is thus adapted to the demands of the work to be done, whether it be thick or thin bars. None of the energy is wasted, and there is no expenditure at all when the welding is not in progress."

The machines now being manufactured are so graded as to apply to various kinds of work, from the smallest wire to bars of over 3 inches in diameter. For heavier work, such as large forgings of locomotive frames, car axles, shafting, etc., special forms of machines adapted to the purpose will be supplied by the company, while

by the use of specially adapted holders and clamps applied to the standard forms of machines, various shapes and irregular sizes of metal pieces may be united without difficulty.



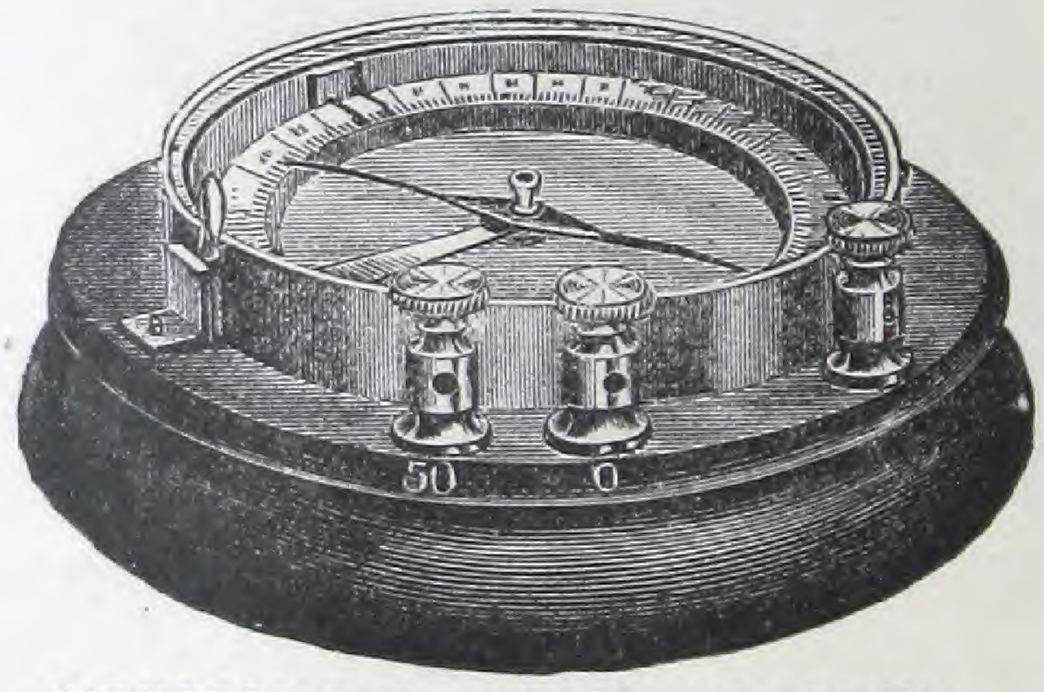
ELECTRIC WELDING MACHINE FOR ONE-INCH RODS.

The machinery which is used for producing currents for welding, is also used with suitable electric devices for electric soldering, brazing, shaping, forging, riveting and bending of metals.

MEASURING INSTRUMENTS.

It is necessary in electrical engineering, as in steam and hydraulic engineering, to take measurements of the forces and quantities used, and for this purpose we have instruments depending on the different effects produced by the electric current. Some depend on the heat produced in a wire carrying the current, others on the magnetic effect of the current, while others depend on its chemical effect. Some of the most important of these instruments are as follows:

Horizontal Galvanometer, for measuring electrical resistances, testing currents, etc. Consists of a light magnetic needle, with agate bearings delicately pivoted on a needle-point, so as to have very little friction, and

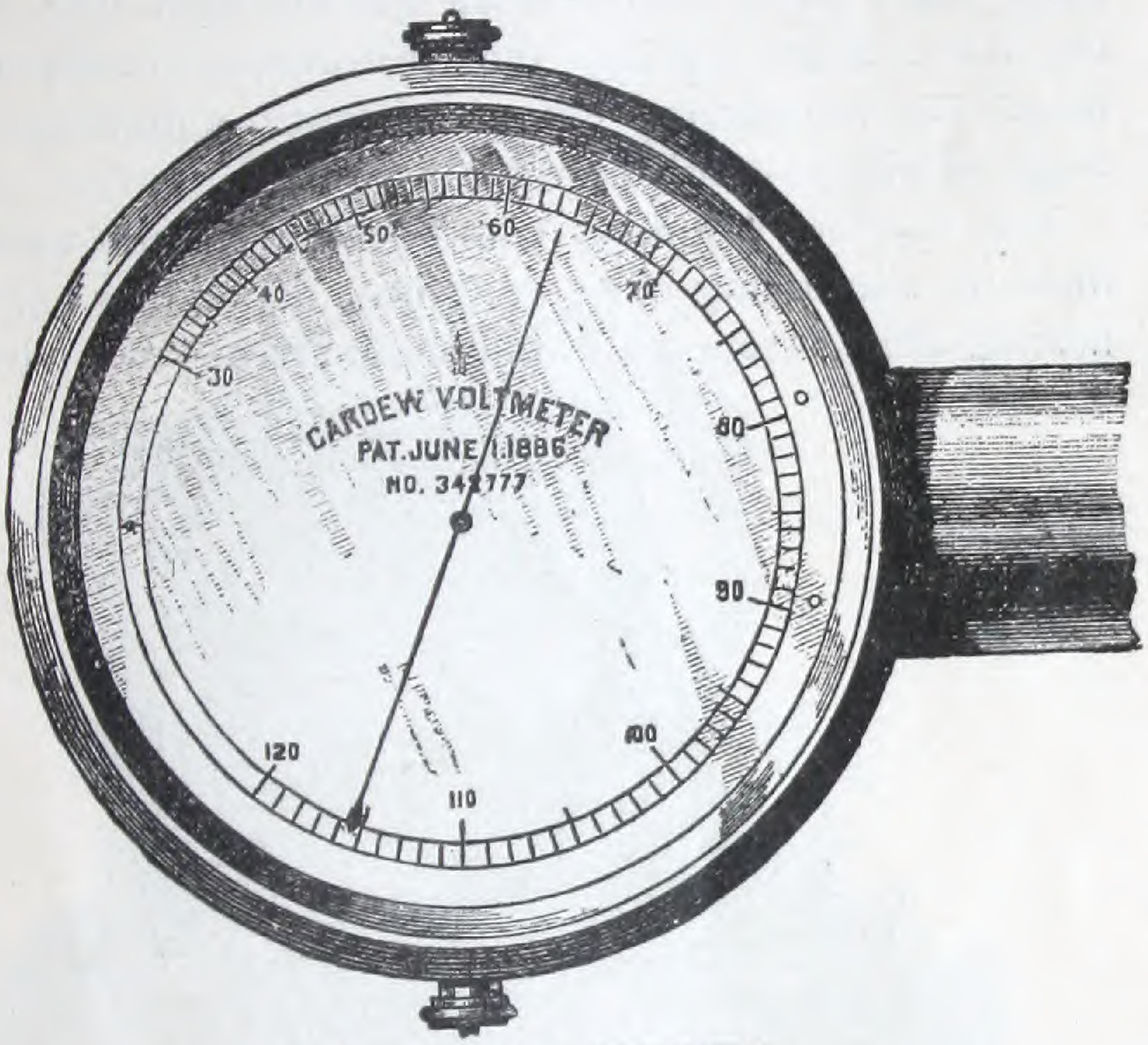


HORIZONTAL GALVANOMETER.

suspended above a flat coil of wire. As an electric current passes through the coil, the needle is deflected out of the

plane of the coil over a scale, and indicating by the amount of its deflection, the intensity of the current.

Cardew Voltmeter.—This instrument differs from the greater number of voltmeters usually employed, in that it makes use of the heating effect of a current instead of its magnetic effect, and the rise of temperature of the conductor is measured by its expansion. This conductor,

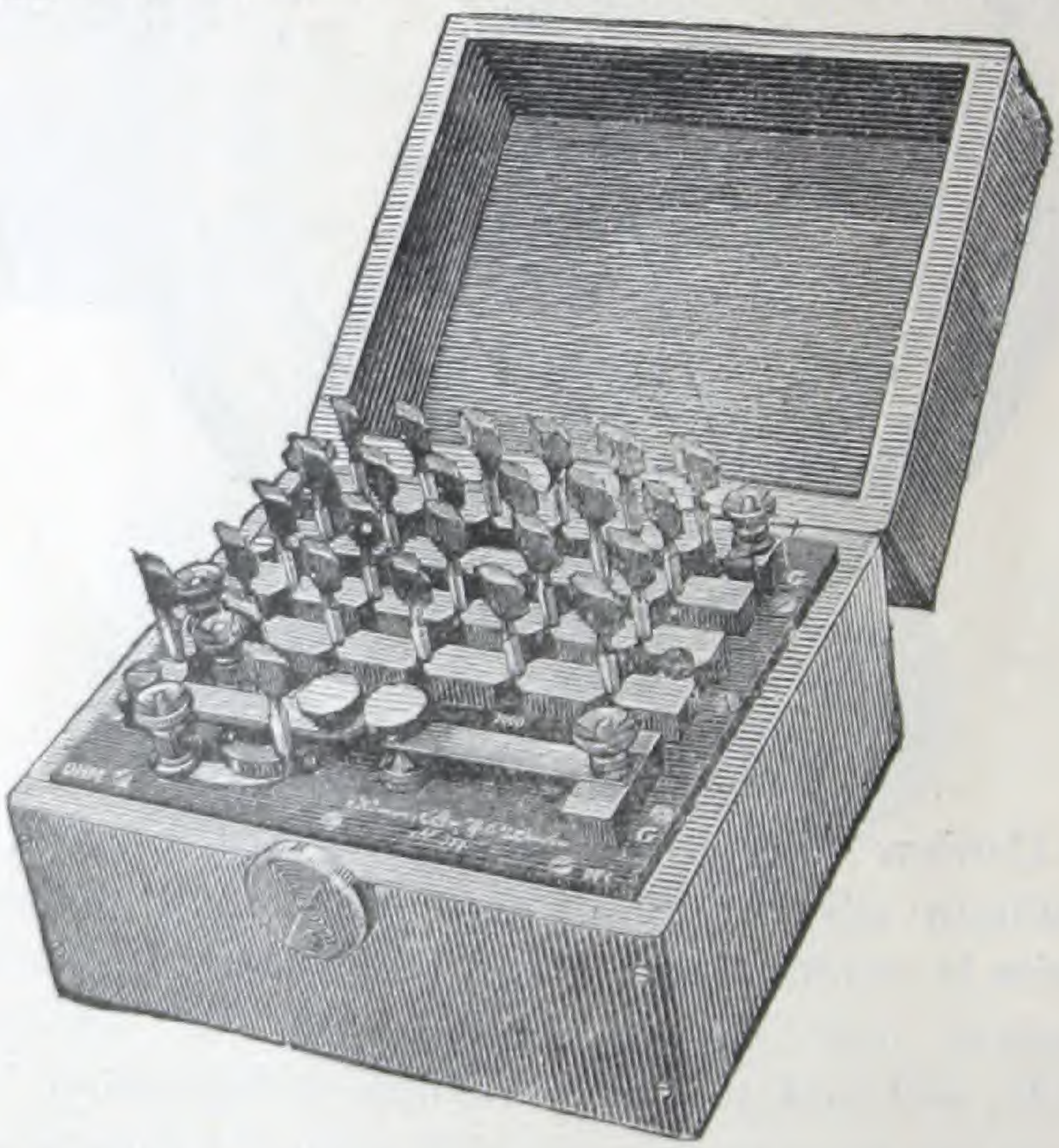


CARDEW VOLTMETER.

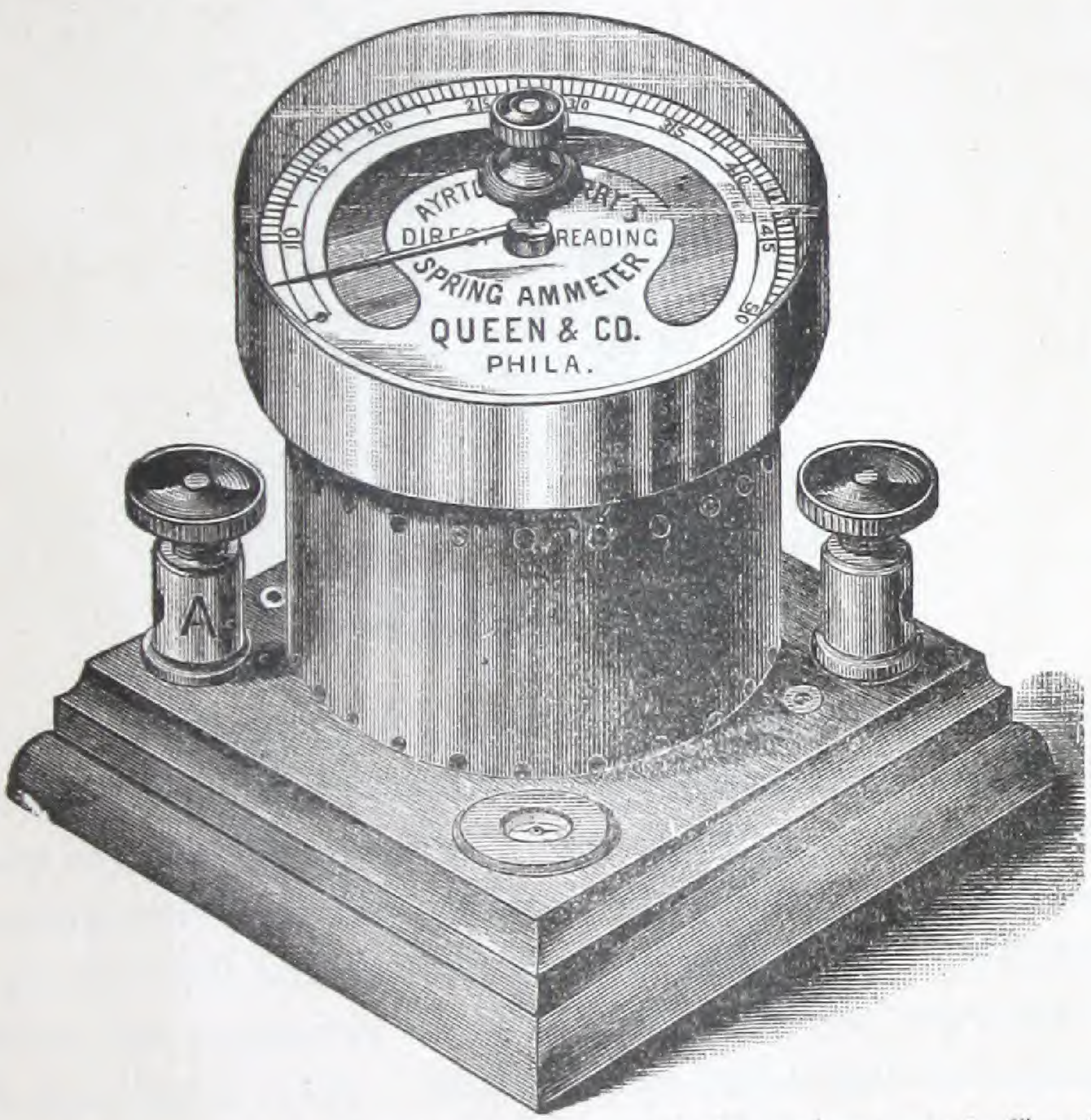
in the Cardew voltmeter, consists of about fourteen feet of platinum silver wire of extremely small diameter; this wire is made to pass along the whole length of the instrument over several pulleys, one of which is movable, and back to a terminal near its beginning. The strain of the wire on this movable pulley is counteracted

by a cord attached to a spiral spring, and passing about a small wheel, which, by its revolution, causes the pointer to be carried over the scale. This, as the wire expands or contracts, the pointer indicates, by its greater or less deflection, the amounts of such change. The advantage in using such a long, fine wire in preference to a shorter one of much greater sectional area, is that the fine wire heats and cools much more quickly than the large one does, thus making the instrument nearly dead heat. By introducing extra resistance, a much greater range of electro-motive force can be used.

The Cardew voltmeter can be used equally well for direct or alternating currents, since, depending only on heating effect, errors of self-induction are not met with.



The Wheatstone's Bridge, illustrated, is for measuring resistance, and consists of a wooden box containing coils of insulated platinum-silver wire, so wound as to avoid self-induction. The coils are made of different sizes of wire, in order to vary their resistance from one to 4,000 ohms, and their ends are connected to the brass blocks seen on the top of the box. A brass plug fits between each two adjacent blocks, and when it is in, it short circuits the coil, whose ends are attached to the blocks. It is by putting in or pulling out these plugs that the resistance in the circuit is varied, in order to make the desired measurement.

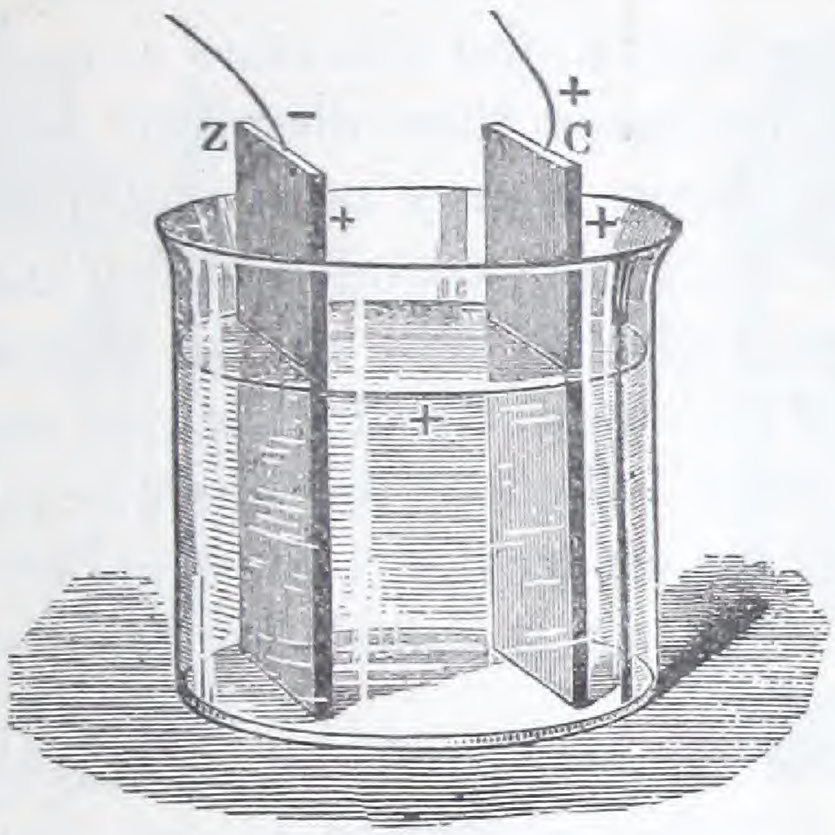


The Ayrton & Perry Spring Voltmeter and Spring Ammeter are constructed on the same principle. Current

is passed through a solenoid, which then has a tendency to suck in any magnetic object. A piece of iron is suspended in the solenoid by means of a peculiarly constructed spring, which, when the iron is drawn down by the action of the current, causes a pointer to move over a scale graduated to read directly in volts or ampères. The illustration is an ammeter; the only difference between that and the voltmeter being in the size of wire used in the solenoid.

ELECTRIC BATTERIES, BELLS, ETC.

Voltaic Cell.—The simplest electric battery made is the Voltaic Cell. This is made by placing in a glass jar some water having a little sulphuric acid or any other oxidizing acid added to it. Then place in it separately two clean strips, one of zinc Z, and one of copper C. This cell is capable of supplying a continuous flow of



electricity through a wire whose ends are brought into connection with the two strips. When the current flows the zinc strip is observed to waste away; its consumption in fact furnishes the energy required to drive the current through the cell and the connecting wire. The cell may, therefore, be regarded as a sort of chemical furnace in which the fuel is zinc. Before the strips are connected by a wire no appreciable difference of potential between the copper and the zinc will be observed by an electro-

meter; because the electrometer only measures the potential at a point in the air or oxidizing medium outside the zinc or the copper, not the potentials of the metals themselves. The zinc itself is at about 1.86 volts lower potential than the surrounding oxidizing media; while the copper is at only about .81 volts lower, having a less tendency to become oxidized. There is then a latent difference of potential of about 1.05 volts between the copper and the zinc; but this produces no current as long as there is no metallic contact. If the strips are made to touch, or are joined by a pair of metal wires, immediately there is a rush of electricity through the metal from the copper to the zinc, and a small portion of the zinc is at the same time dissolved away; the zinc parting with its latent energy as its atoms combine with the acid. This energy is expended in forcing a discharge of electricity through the acid to the copper strip, and thence through the wire circuit back to the zinc strip. The copper strip, whence the current starts on its journey through the external circuit, is called the positive pole, and the zinc strip is called the negative pole.

Electric Batteries may be classified according to their use into open circuit and closed circuit batteries. An open circuit battery is a battery which is used when a current is needed for a few seconds at a time. If the circuit is kept closed too long the battery will become polarized, that is, hydrogen will collect on the carbon and prevent the current passing through the circuit. If, however, the circuit is opened the battery will recover itself in time. These batteries are designed for bells, telephones, gaslighters, etc.

To this class belong the Leclanche, Samson and Law.

Closed circuit batteries are used for continuous work-as for electric lighting, electro plating, fire alarms, etc.

To this class belong the Grenet, Gravity, Gove, Bunsen and Fuller batteries.

The Leclanche Battery.—In this cell the exciting liquid is a solution of sal-ammoniac. In this the zinc dissolves, while ammonia gas and hydrogen are liberated at the carbon pole.

To prevent polarization in the disque form, the carbon plate is packed inside a porous cell with fragments of

carbon and powdered binoxide of manganese, which slowly yields oxygen, and destroys the hydrogen bubbles.

In the prism form the binoxide of manganese is applied in plaques or prisms, thus avoiding the necessity of using a porous cell.

The Leclanche cell will give a continuous current only for a short time, the power falling off, owing to the accumulation of hydrogen bubbles; if the circuit is left open for a time the cell recovers itself, the binoxide gradually destroying the polarization.

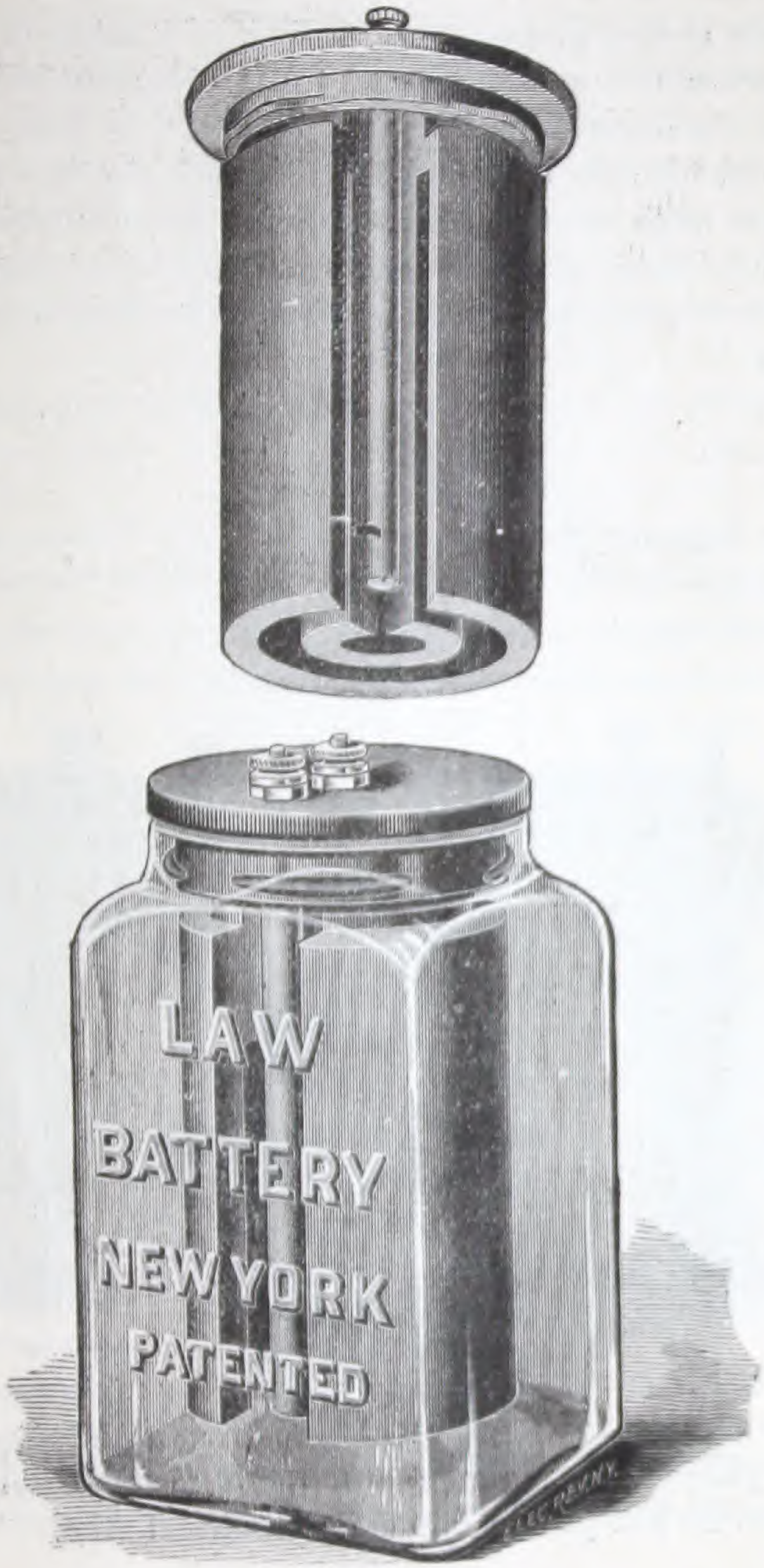
The cell is in other respects perfectly constant, very clean, and as it does not require renewing for months or years, when closed only for a few seconds at a time, it is well adapted for working electric bells, annunciators, burglar alarms, and for other domestic purposes. This battery is set up in the following manner:

Put six ounces of sal-ammoniac into the glass jar, fill one-third full of water, and stir. Put in the porous cell and fill with water to the neck of the jar, pouring a little water into the hole in the porous cup. Put in the zinc and connect the battery.

The inside of the rim of the jar is paraffined, and should be kept greased to keep the salts from creeping.

The battery should be kept in a dry place of medium temperature. It requires very little attention; water should be poured in occasionally to supply the loss by evaporation. In case the solution becomes milky, and the battery fails to work, the solution should be thrown out and fresh sal-ammoniac and water put in. If this does not restore the battery, soak the porous cell in warm water. If it still fails, new porous cells must be used.

Law Battery.—The jar is of flint glass, four and a quarter inches square and seven inches high. The lid is of hard rubber composition and has three lugs on its flange, which engage with three on the inside of the mouth of the jar, thereby locking the lid hard down against a soft rubber washer. The negative element is a double cylinder of pure carbon, weighing about twenty ounces and having a very large surface—about 147 square inches. The positive element is a rolled rod of zinc; the excitant, 2 and 1-2 pints of sal-ammoniac solution. A carbon button specially prepared is interposed between the negative element and its metal binding post to protect the lat-


LAW
BATTERY
NEW YORK
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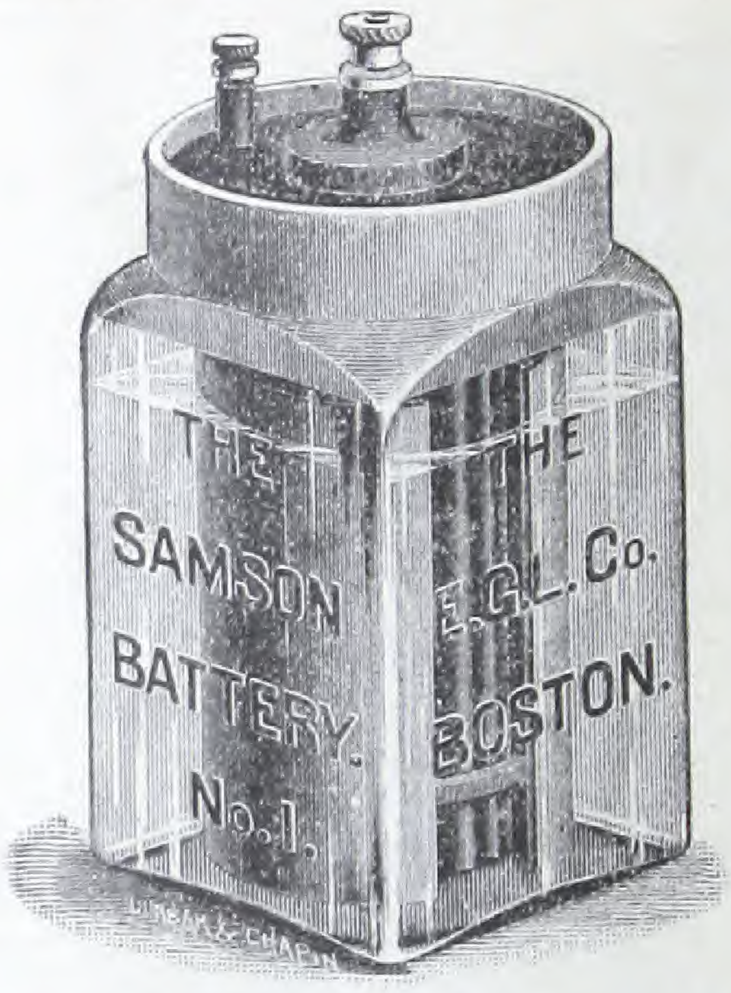
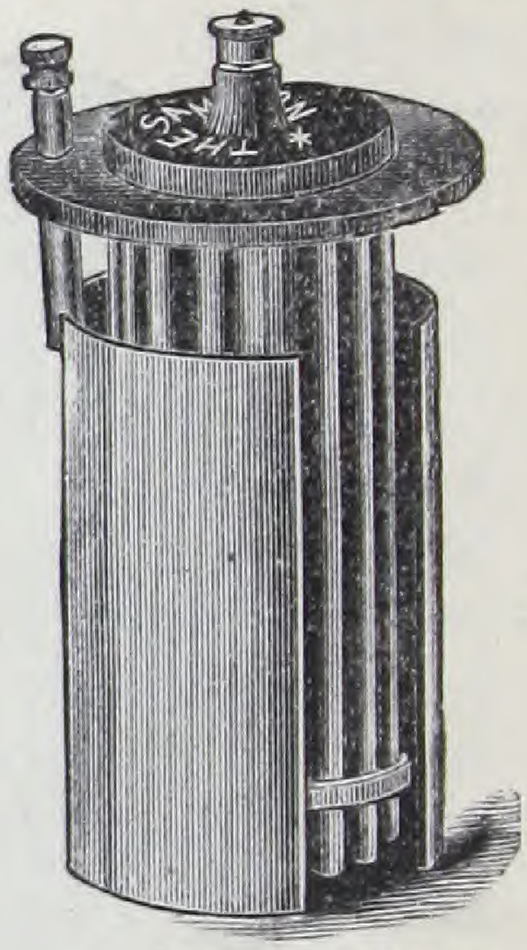
ter from corrosion—a fruitful source of trouble in other batteries of this class. The very large quantity and surface of the negative element (being three or four times the usual quantity and surface in batteries of this class) and the large quantity of solution (about double that ordinarily used, gives the battery a very low resistance and a very great holding up power under hard or excessive use.

Its E. M. F. is about 1.5 volts, internal resistance, .5 of an ohm.

The Samson Battery.—This battery in France, where first manufactured, is the leading open-circuit battery.

This battery is not only presented for its great efficiency in call bell, annunciator, burglar alarm and gas-lighting





Zinc, Carbon and Cover.

work, but it is also especially adapted to telephone service on account of its remarkable endurance and long life.

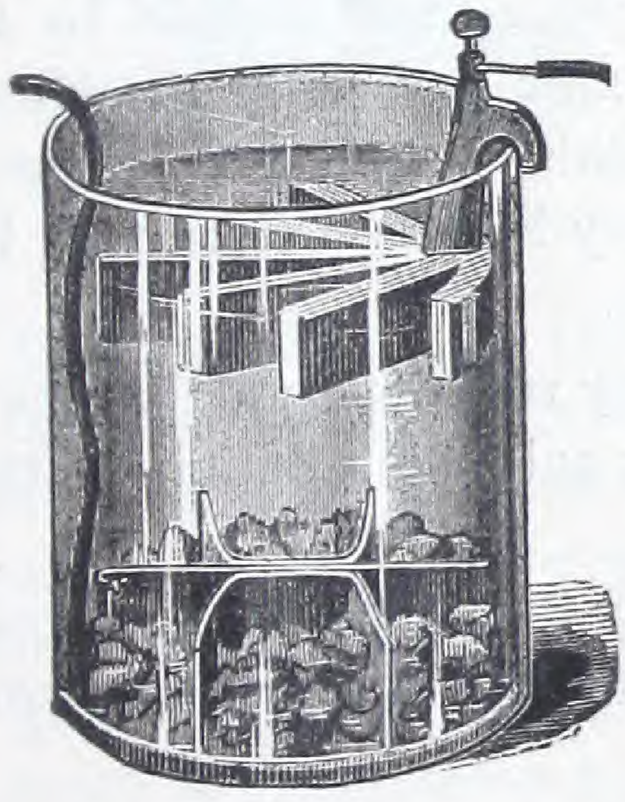
The essential characteristics of the Samson Battery are its fluted carbon porous cup and cylindrical zinc.

The former is imported direct from the Paris manufacturer in order to insure the perfection of quality which he has reached by years of practical experiment.

The carbon cup is corrugated, to present a much larger surface to the action of the solution; is porous to render the flow of the solution into the cup unresisted; is filled with a depolarizing material, to add to the battery durability and recuperative power. The zinc is of the best quality, well amalgamated, presents to the solution an unusually large surface, and nearly surrounds the carbon cup, thus reducing the internal resistance of the battery to almost nothing.

The neck of the jar has a choke which supports a rubber cover, to prevent evaporation, closely fitting the corrugated carbon, which it holds safely apart from the zinc. In this cell the exciting liquid is a solution of sal-ammoniac.

Gravity Batteries are two fluid cells. The one shown in the engraving is the Crowfoot Battery.



Instead of employing a porous cell to keep the two liquids separate, it is possible, where one of the liquids is

heavier than the other, to keep the latter on the bottom, and have the lighter floating upon it; this separation, however, is never perfect, the heavy liquid slowly diffusing upward.

To set up this battery proceed as follows:

Open out the copper, so as to present all of its surface to the action of the solution, place it in the bottom of the jar, run the insulated wire out of the top of the jar for connecting up.

Suspend the zinc above the copper by hanging the hooked neck on the rim of the glass.

Pour clean soft water into the jar until it covers the zinc, then drop in six or eight ounces of copper sulphate (blue vitriol) in small crystals.

Connect the battery (for ordinary purposes) zinc of one cell to copper of the next and so on, and connect the two electrodes of the series and let them so remain for a few hours, until the separation of the two solutions, which will be known by the blue observed in bottom of copper solution. This "blue line" should be maintained midway between the zinc and copper; when it is too low, drop in a few crystals of copper sulphate, when too high, connect the battery in short circuit as before described until it goes down.

While the battery remains in action there is an increase in quantity of zinc sulphate solution in the upper part of the jar.

When zinc oxide forms on the surfaces of the zinc, it must be taken out and washed in clean water with a brush.

The Grenet Battery, shown in the engraving, consists of a glass jar or bottle. A well amalgamated zinc plate

forms one pole and a pair of carbon plates, one on each side of the zinc, joined at the hard rubber top, forms the other pole. The zinc plate is fixed to a brass rod, by which it can be drawn up out of the solution when not in use. To charge this battery proceed as follows:

To three pints of cold water add five fluid ounces of

GRENET BATTERY.

sulphuric acid. When this becomes cold add six ounces (or as much as the solution will dissolve) of finely pulverized bichromate of potash. Mix well.

Pour the above solution into the glass cell until it nearly reaches the top of the spherical part; then draw up the zinc and place the element in the cell. The fiuid should not quite reach the zinc when it is drawn up.

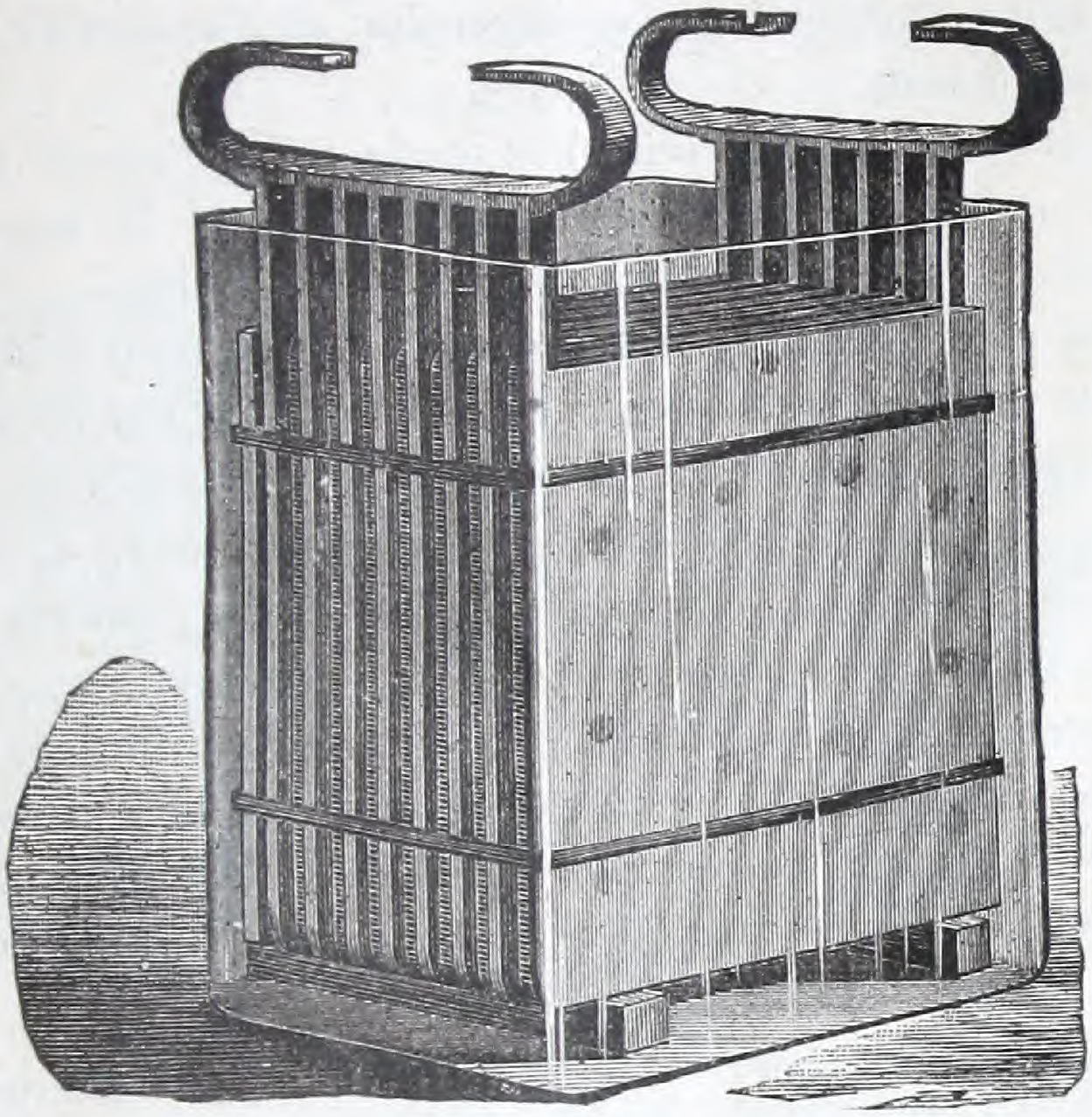
Dry Batteries.—It is often necessary to arrange batteries so that they may stand considerable jarring, or even overturning, when a liquid would be spilled. Therefore

came the invention of the Dry Battery. Of this type the Standard Dry Battery is one of the leading batteries of the present time. The battery shown in the cut is made by filling in the space between a hollow carbon cylinder and a metal plate which faces both external and internal surfaces of the cylinder, with the chemicals in a dry,

or rather pasty form. The whole is then sealed tight into the covering and is ready for use. Neither of the elements is consumed during action, but the chemicals are decomposed. It is, therefore, free from the effects of polarization during the greater portion of its life, and can be restored again when exhausted by passing a current from its positive to its negative pole,

being thus, in a certain sense, a storage battery. Its E. M. F. is about 2 volts, and it will give a current of from 6 to 10 amperes, as its internal resistance is very low.

Storage Batteries or Accumulators.—The possibility of storing electricity was first suggested in 1801, by Gautherot's discovery that two plates of the same metal



immersed in acid, after having been subjected to the action of an electric current in one direction, would produce a secondary current in the opposite direction.

In 1859 Gaston Planté, while engaged in a series of experiments upon this phenomenon, devised a storage battery consisting of plates of lead immersed in dilute sulphuric acid.

Camille A. Faure, after many experiments in this field,

made the remarkable discovery that a paste of oxide of lead mechanically applied to the plates, brought them instantly into the condition to receive a charge which was only accomplished by Planté after months of electrical treatment.

One of the best storage batteries of the present day is the Electrical Accumulator Co.'s battery shown in the engraving, combining the invention of Faure with many improvements.

This cell (see engraving) is made up of fifteen plates, eight negatives and seven positives, and is especially adapted to isolated and central station lighting.

The electro-motive force of the cell is about 2 volts.

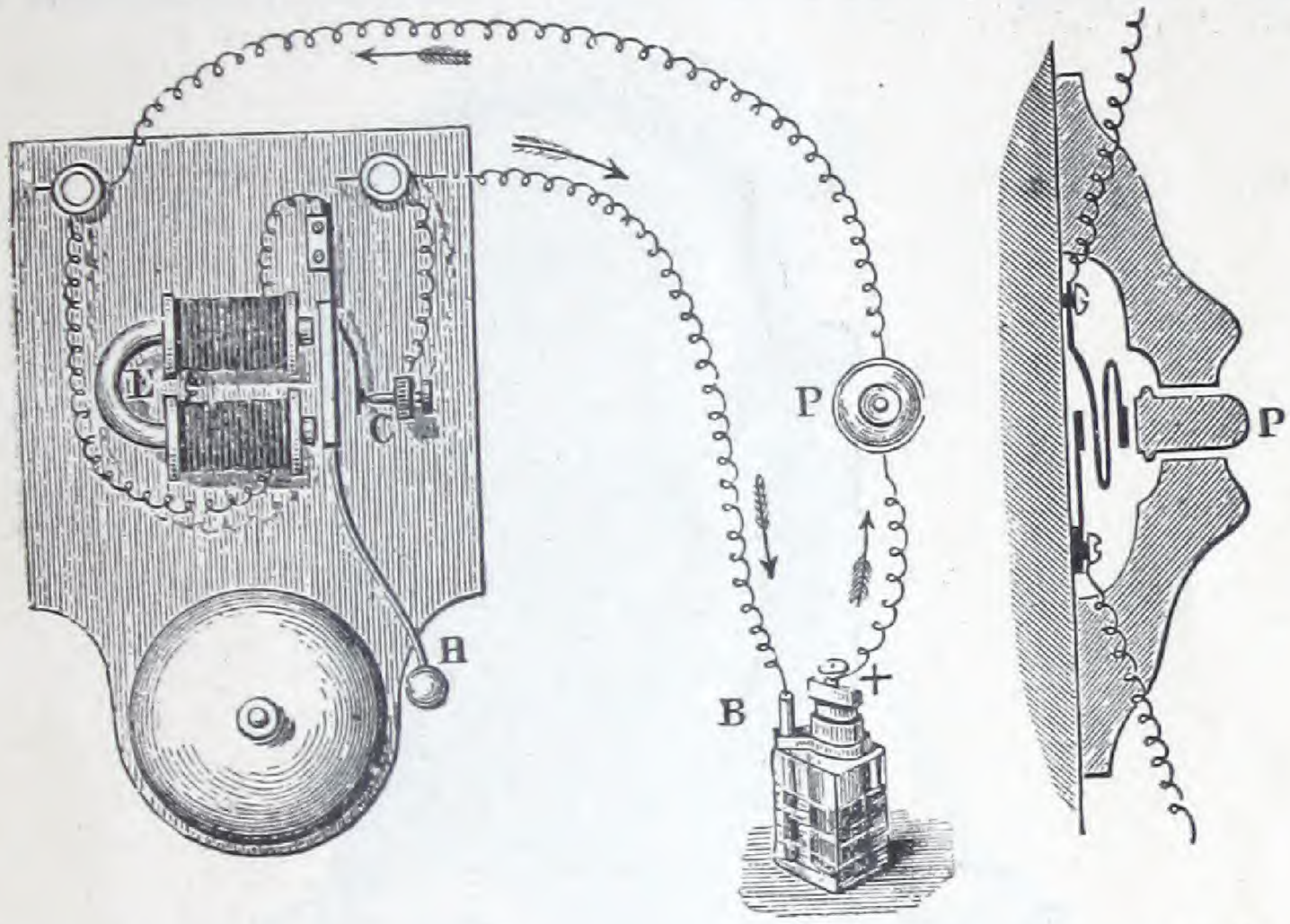
The internal resistance is extremely low, say from .001 to .005 ohm, and the range of the current large.

The capacity of the cell in perfect condition is somewhat underestimated at 300 ampere-hours; 30 amperes, a safe working current, will last for over ten hours, with not exceeding 10 per cent. drop in electro-motive force, or a less current will be supplied by the cell for a proportionately greater number of hours. A greater rate—up to 300 amperes—could also be obtained, but so great a strain upon this size of cell would injure the plates.

Storage batteries can be used for electric lighting, stationary and locomotive power, electro-plating, telegraphy, medical and surgical purposes, etc.

Electric Bells.—The common form of electric bell or trembler consists of an electromagnet, which moves a hammer backward and forward by alternately attracting and releasing it, so that it beats against a bell. The arrangements of the instrument are shown in the diagram, in which E is the electromagnet and H the hammer. A

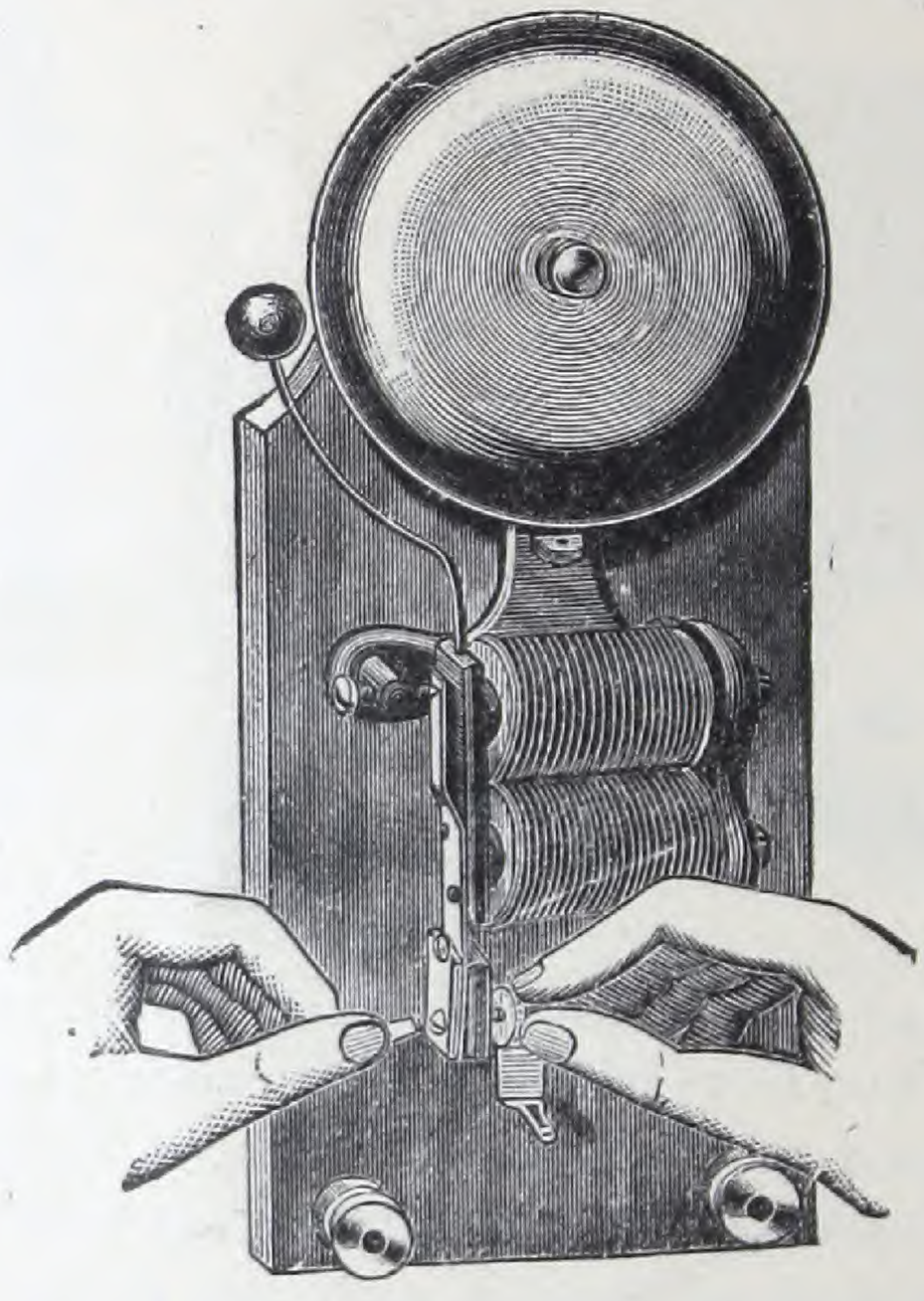
battery, consisting of one or two Leclanche cells placed at some convenient point of the circuit, provides a current when required. By touching the "push" P the circuit is completed, and a current flows along the line and round the coils of the electromagnet, which forthwith attracts a small piece of soft iron attached to the lever, which terminates in the hammer H. The lever is itself included in the circuit, the current entering it above and quitting it at C by a contact-breaker, consisting of a



spring tipped with platinum resting against the platinum tip of a screw, from which a return wire passes back to the zinc pole of the battery. As soon as the lever is attracted forward the circuit is broken at C by the spring moving away from contact with the screw; hence the current stops, and the electromagnet ceases to attract the armature. The lever and hammer therefore fall back, again establishing contact at C, whereupon the hammer is once more attracted forward, and so on. The push P

is shown in section on the right. It usually consists of a cylindrical knob of ivory or porcelain capable of moving loosely through a hole in a circular support of porcelain or wood, and which, when pressed, forces a platinum-tipped spring against a metal pin, and so makes electrical contact between the two parts of the interrupted circuit.

The Victor Wooden Box Bell.—Its superiority consists in a soft iron bed-plate, to protect the adjustment from warping of the base-board; a double adjustment of

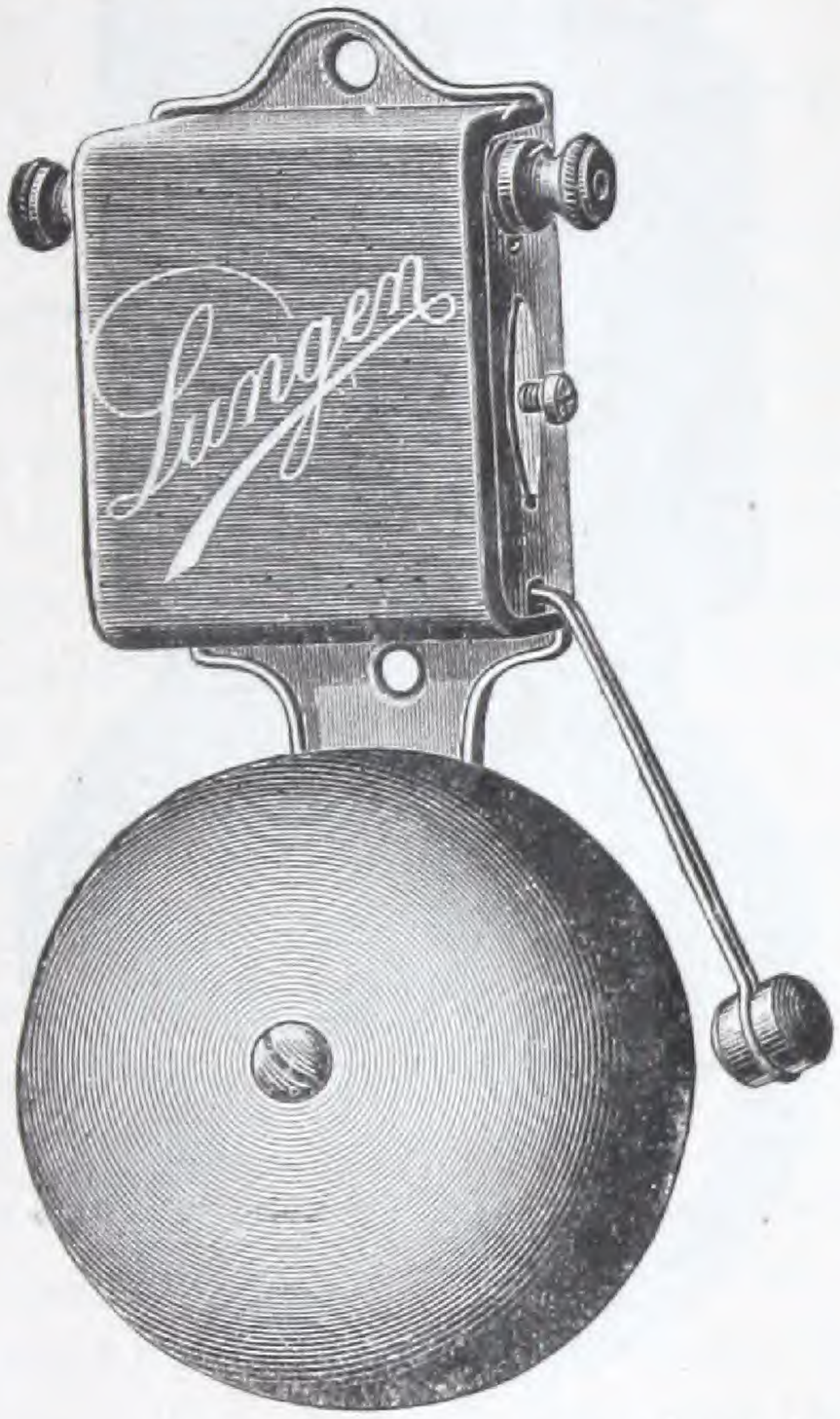


the tension of spring as well as length of stroke; a novel and convenient clasping device for fastening the box to base-board; platinum contact points, and gongs of superior tone. The magnets of the 2 1-2, 3 and 3 1-2 inch

bells are wound to three ohms resistance, and the gongs, binding posts, armature and hammer are all nickel plated. Finished in black walnut, plain and stained cherry, oak and ash boxes.

The accompanying engraving shows the Victor Bell uncovered.

The Lungen Bell is entirely new in construction. The base and cover are stamped, and having ribbed edges are

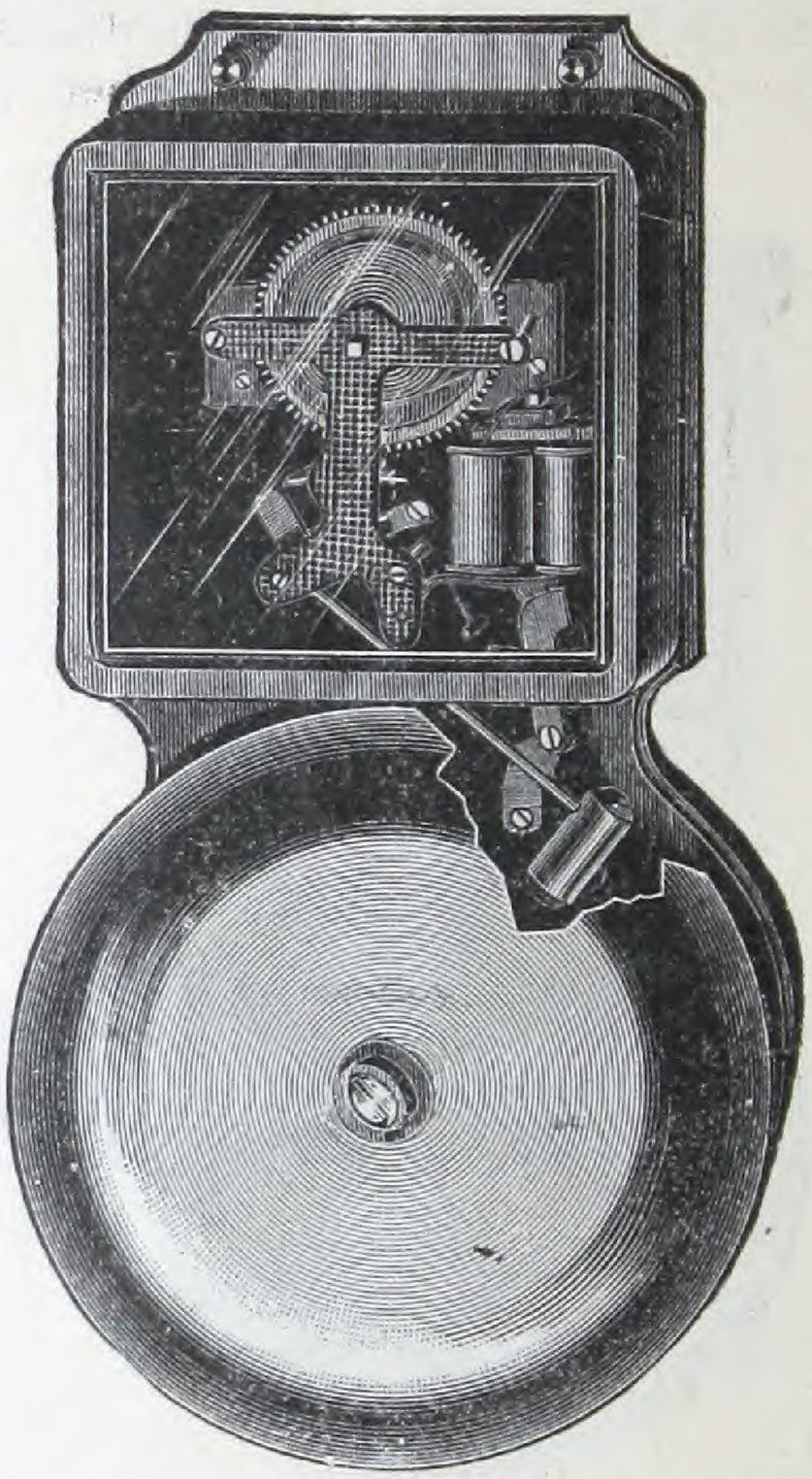


strong, light and compact. Every piece is interchangeable, special machinery being used in its manufacture.

The armature, hammer and its rod and adjusting springs are combined so that they cannot work loose. The

adjusting screw is held firmly by spring nut and always remains as set. The base and metal parts are nickel plated. The cover is made to spring on and requires no fastening. The hammer rod passes through the side of base, thereby filling opening making it dust and insect proof.

The Star Electro-Mechanical Gong.—The Star Gong



is designed for use on railroads, in fire department stations, factories, engine rooms, school houses, etc., where unerring alarms are requisite.

The mechanism is simple, and its operation accurate.

The release, controlled by the electro-magnet, is provided with an attachment which holds the hammer in position, except at the instant the current ceases, thus preventing more than one stroke for each pressure of the key. The hammer thus released falls into position for the blow, releases a stop-lever, and sets in motion a spring mechanism geared to a five-pointed star, one point of which forces the hammer to strike the blow. The hammer itself is faced with lignum vitæ, to render the alarm more agreeable to the ear.

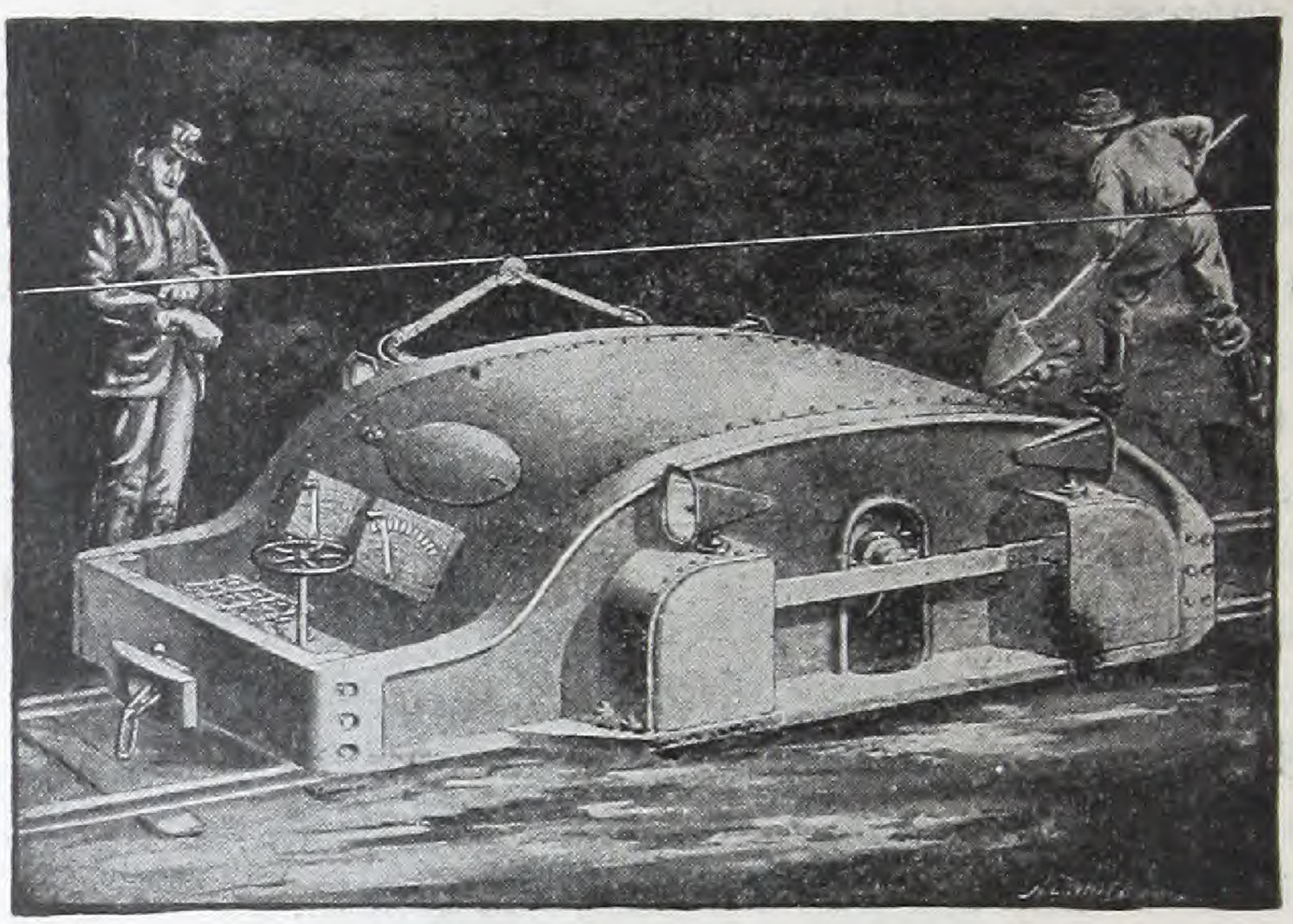
One winding of the spring (not clockwork) will serve 300 blows upon the gong.

The magnets may be wound to any desired resistance to suit the requirements of any circuit. The large sized gongs are fitted to order for use on reversal circuits. Continuous ringing attachments are furnished with the gongs, when so ordered, without additional cost.

The instrument is weather-proof, provided with lightning arrester, and mounted in handsomely finished black walnut or ash cases, with plate glass fronts.

The Thomson-Van Depoele Mine Locomotive.—The general appearance of the Thomson-Van Depoele locomotive is shown in illustration. The No. 4 machine, with a capacity of 60 horse-power, has a total height from top of rail of 39 inches. The controlling devices are all at one end, and the body of the locomotive being so low that the view is unobstructed in either direction, the operator need not change his position in reversing the motion of the locomotive. Two Electric Parabolic Reflectors are provided at each end, making the track clearly visible for long distances. The trolley is of the double-elbow pattern, found so admirably suited to mine work in

previous installations. It accommodates itself to the varying heights of the trolley wire within any reasonable range. The sheet-iron makes a complete water-tight armor, protecting the moving part from danger of fallen



THOMSON-VAN DEPOELE MINING LOCOMOTIVE.

rocks or bodies of ore and coal. The illustration shows the locomotive in an enlarged chamber, but about to enter a tunnel whose height from top of rail is scarcely four feet, hence the depression of the trolley wire as shown.

TABLES FOR INCANDESCENT WIRING.

TABLE SHOWING THE DIFFERENCE BETWEEN WIRE GAUGES.

No.	*New British.*	*London.*	*Stubs'.*	*Brown & Sharpe's.*
0000	.400	.454	.454	.460
000	.372	.425	.425	.40964
00	.348	.380	.380	.36480
0	.324	.340	.340	.32495
1	.300	.300	.300	.28930
2	.276	.284	.284	.25763
3	.252	.259	.259	.22942
4	.232	.238	.238	.20431
5	.212	.220	.220	.18194
6	.193	.203	.203	.16202
7	.176	.180	.180	.14428
8	.160	.165	.165	.12849
9	.144	.148	.148	.11443
10	.128	.134	.134	.10189
11	.116	.120	.120	.09074
12	.104	.109	.109	.08081
13	.092	.095	.095	.07196
14	.080	.083	.083	.06408
15	.072	.072	.072	.05706
16	.064	.065	.065	.05082
17	.056	.058	.058	.04525
18	.048	.049	.049	.04030
19	.040	.040	.042	.03589
20	.036	.035	.035	.03196
21	.032	.0315	.032	.02846
22	.028	.0295	.028	.025347
23	.024	.027	.025	.022571
24	.022	.025	.022	.0201
25	.020	.023	.023	.0179
26	.018	.0105	.018	.01594
27	.0164	.01875	.016	.014195
28	.0148	.0165	.014	.012641
29	.0136	.0155	.013	.011257
30	.0124	.01375	.012	.010025
31	.0116	.01225	.010	.008928
32	.0108	.01125	.009	.00795
33	.0100	.01025	.008	.00708
34	.0092	.0095	.007	.0063
35	.0084	.009	.005	.00561
36	.0075	.0075	.004	.005

TABLE No. 1

For House Wiring and Secondary Mains.

PER CENT. LOSS.	100 VOLTS.	50 VOLTS.	50 VOLTS, 3 WIRE.	50 Volt Lamp.	100 Volt Lamp.
				On 200 Volts.	
1	12.6	42.	10.5	2.62	3.15
2	6.3	21	5.25	1.31	1.58
3	4.2	14.	3.5	.87	1.05
4	3.15	10.5	2.63	.66	.79
5	2.52	8.4	2.1	.52	.63
6	2.1	7	1.75	.44	.53
8	1 58	5.25	1.31	.33	.39
10	1.26	4.2	1.05	.26	.32
12	1.05	3.5	.88	.22	.26
15	.84	2.8	.7	.17	.21
20	.63	2.1	.53	.13	.16

EXAMPLE OF TABLE NO. 1.—Required wire for 13, 16 c. p. lamps, 30 feet, 1 per cent. loss.

13x30x12.6=4914 c. m.,=No. 13 wire.

EXAMPLE OF TABLE NO. 2.—Required size and cost of wire at 18 cents per lb., to carry 500 16 c, p. 100 volt lamps, 2,200 feet on 1,000 volts, and 2 per cent. loss.

500x2200x.063=69300 c. m.,=No. 2 wire.

4,400 feet of No. 2 costs 4,400x.0433=$186 12.

EXAMPLE OF TABLE NO. 3.—Wanted wire for 2,500, 16 c. p., 50 volt lamps, 5,280 feet, at 3.000 volts and 3 per cent loss.

2,500x5280x.0039=51,480 c. m.,=No. 3 wire.

10,560x0344=$363.26.

TABLE No. 2.

For Primary Mains and 100 Volt 16 c. p. Lamps.

Per Cent. Loss.	1000 Volts.	2000 Volts.	3000 Volts.	Volts. 4000	5000 Volts.
1	126	0315	014	.0079	005
2	.063	0157	007	004	0025
3	.042	.0105	.0047	.0026	0017
4	.0315	.0079	.0035	.002	.0013
5	.0252	.0063	.0028	.0016	.001
6	.021	.0052	.0023	.0013	.0008
8	0158	.0039	.0017	001	0006
10	0126	.0031	.0014	0008	.0005
12	0105	.0026	0012	0007	0004
15	0084	.0021	0009	0005	.0003
20	.0063	.0016	.0007	.0004	00025

TABLE No. 3.

For Primary Mains and 50 Volt 16 c. p. Lamps.

Per Cent. Loss.	1000 Volts.	2000 Volts.	3000 Volts.	4000 Volts.	5000 Volts.
1	.105	.0262	.0117	.0066	.0042
2	.0525	.0131	.0058	.0033	.0021
3	.035	.0088	.0039	.0022	.0014
4	.0262	.0066	.0029	.0017	.0011
5	.021	.0053	.0023	.0013	.0008
6	.0175	.0044	.0019	.0011	.0007
8	.0131	.0033	.0015	.0008	.0005
10	.0105	.0026	.0012	.0007	.0004
12	.0088	.0022	.001	.0006	.0004
15	.007	.0018	.0008	.0004	.0003
20	.0052	.0013	.0006	.0003	.0002

TABLE OF WIRE "B. AND S." GAUGE.

B. & S. No.	Diam. in 1000 Inch.	Area in Cir. Mills. $A=D^2$	Lbs. per M. bare.	Lbs. per M. covered.	Resist'c'e in ohms per foot.	Ohms per Foot Covered, At 16c. lb.	Ohms per Foot Covered, At 15c. lb.	Ohms per Foot Covered, At 20c. lb.
0000	.460	211600	.639	.821	.0000491	.1314	.1478	.1642
000	.410	167805	.507	.619	.0000619	.099	.1114	.1238
00	.365	133079	.402	.441	.000078	.0706	.0794	.0882
0	.325	105592	.319	.356	.000983	.057	.0641	.0712	
1	.289	83694	.253	.284	.000124	.0454	.0511	.0568	
2	.258	66373	.201	.235	.0001564	.0376	.0423	.0470	
3	.229	52634	.159	.191	.0001974	.0306	.0344	.0382	
4	.204	41742	.126	.158	.0002487	.0253	.0284	.0316	
5	.182	33102	1	.127	.0003136	.0203	.0229	.0254	
6	.162	26250	.079	.102	.0003965	.0163	.0184	.0204	
7	.144	20816	.063	.085	.0004997	.0136	.0153	.017	
8	.128	16509	.05	.069	.0006298	.011	.0124	.0139	
9	.114	13094	.04	.054	.0007928	.0096	.0097	.0109	
10	.102	10381	.031	.047	.001	.0075	.0085	.0094	
11	.091	8234	.025	.036	.0012607	.0056	.0065	.0073	
12	.081	6530	.02	.031	.0015899	.005	.0056	.0061	
13	.072	5178	.016	.026	.0020047	.0042	.0047	.0052	
14	.064	4107	.012	.02	.0025909	.0032	.0036	.004	

STANDARD GAUGE.

BROWN & SHARP.

GENERAL FORMULA FOR WIRING.

A—Area required wire in cir. mills.
D—Single distance.
N—Number lamps of any voltage
C—Current in amperes per lamp.
E—*Number volts* per lamp lost in line.
R—Ratio of conversion (if any).

FOR STREET WIRING (PRIMARY CURRENTS.)

$$A=\frac{21xDxNxC.}{ER^2.}$$

EXAMPLE:—Required size of primary wire (B. & S. Gauge), to carry 650, 16 c. p., 50 volt lamps, each using 1 ampere of current, a distance of 3,600 feet, on a loss of 3 per cent., with an E. M. F. of 1,000 volts. A drop of 3 per cent. on a 50 volt lamp is 1.5 volts, and the ratio of conversion is $\frac{1000}{50}=20$.

$$A=\frac{21x3600x650x1}{1.5(20x20.)}=81,900 \text{ cir. mills.}$$

which is practically a No. 1 wire, (see Table No. 4).

FOR HOUSE WIRING (SECONDARY CURRENTS)

$$A=\frac{21xDxNxC.}{E.}$$

EXAMPLE: Required size of wire to carry 12 16 c. p., 100 volt lamps, each using .6 amperes, a distance of 80 feet, on a loss of 1 per cent.

$$A=\frac{21x80x12x.6.}{1}=12,096 \text{ c. m., = No. 9 wire.}$$

For practical use the following tables, based on the above formula will be found preferable. They are calculated for 16 c. p. lamps only.

THE THOMSON HOUSTON SYSTEM.

WIRING TABLE. 16-CANDLE

52 Volt Lamps.	75 Volt Lamps.	110 Volt Lamps.	220 Volt Lamps.	330 Volt Lamps.	Distance in feet to center of Distribution.						
					20'.	25'.	30'.	40'.	50'.	60'.	70'.
1	1.3	1.5	3.	5.	16.	16.	16.	16.	16.	16.	16.
1.5	2.	2.5	5.	7.	16.	16.	16.	16.	16.	16.	15.
2	2.6	3.	6.	10.	16.	16.	16.	16.	16.	16.	15.
3.	4.	5.	10.	15.	16.	16.	16.	16.	15.	14.	13.
4.	5.	7.	13.	20.	16.	16.	16.	15.	13.	13.	12.
5.	6.	8.	16.	25.	16.	16.	15.	13.	13.	12.	11.
6.	8.	10.	20.	30.	16.	15.	14.	13.	12.	11.	11.
7.	9.	11.	23.	35.	15.	14.	13.	12.	11.	11.	10.
8.	10.	13.	26.	40.	15.	14.	13.	12.	11.	10.	9.
9.	12.	15.	30.	45.	14.	13.	12.	11.	10.	9.	9.
10.	13.	16.	33.	50.	14.	13.	12.	11.	10.	9.	8.
12.	16.	20.	40.	60.	13.	12.	11.	10.	9.	8.	8.
14.	18.	23.	46.	70.	12.	11.	10.	9.	8.	7.	7.
16.	20.	26.	53.	80.	12.	11.	10.	9.	8.	7.	6.
18.	23.	30.	60.	90.	11.	10.	9.	8.	7.	6.	6.
20.	27.	33.	66.	100.	11.	10.	9.	8.	7.	6.	5.
25.	33.	41.	83.	125.	10.	9.	8.	7.	6.	5.	4.
30.	40.	50.	100.	150.	9.	8.	7.	6.	5.	4.	3.
35.	46.	58.	116.	175.	8.	7.	7.	5.	4.	4.	3.
40.	52.	66.	133.	200.	8.	7.	6.	5.	4.	3.	2.
45.	59.	75.	150.	225.	7.	6.	5.	4.	3.	2.	2.
50.	65.	83.	166.	250.	6.	6.	5.	4.	3.	2.	1.
55.	72.	91.	183.	275.	6.	5.	5.	3.	2.	2.	1.
60.	79.	100.	200.	300.	5.	5.	4.	3.	2.	1.	0.
65.	85.	108.	216.	325.	5.	5.	4.	3.	2.	1.	0.
70.	92.	116.	233.	350.	4.	4.	4.	2.	1.	1.	0.
75.	98.	125.	250.	375.	4.	4.	3.	2.	1.	0.	00.
80.	105.	133.	266.	400.	3.	3.	3.	2.	1.	0.	00.
90.	118.	150.	300.	450.	3.	3.	2.	1.	0.	00.	00.
100.	131.	166.	333.	500.	2.	2.	2	1.	0.	00.	000.

POWER LAMPS LOSS 1 VOLT

Wire sizes are indicated below in B. & S. gauge.								Gauge Number.	Carrying Capac'y in Amperes.
80'.	90'.	100'.	120'.	140'.	160'.	180'.	200'.		
16.	16.	16.	16.	15.	14.	14.	13.	16.	3.9
15.	15.	14.	14.	13.	13.	12.	11.	15.	4.9
15.	14.	13.	13.	12.	12.	11.	10.	14.	6.2
13.	12.	12.	11.	10.	10.	9.	9.	13.	7.9
11.	11.	10.	10.	9.	8.	8.	7.	12.	9.9
11.	10.	10.	9.	8.	8.	7.	7.	11.	12.5
10.	10.	9.	8.	8.	7.	7.	6.	10.	15.
9.	9.	8.	8.	7.	6.	6.	5.	9.	20.
9.	8.	8.	7.	6.	6.	5.	5.	8.	25.
8.	8.	7.	6.	6.	5.	5.	4.	7.	32.
8.	7.	7.	6.	5.	5.	4.	4.	6.	40.
7.	7.	6.	5.	5.	4.	4.	3.	5	50.
6.	6.	5.	4.	4.	3.	3.	2.	4	63.
6.	5.	5.	4.	3.	3.	2.	2.	3.	80.
5.	5.	4.	3.	3.	2	2.	1.	2.	101.
5.	4.	4.	3.	2.	2.	1.	1.	1.	127.
4.	3.	3.	2.	1.	1.	0.	0.	0.	161.
3.	2.	2.	1.	0.	0.	0.	00.	00.	202.
2.	2.	1.	1.	0.	00.	00.	000.	000.	255.
2.	1.	1.	0.	00.	000.	000.	000.	0000.	322.
1.	1.	0.	00.	00.	000.	000.	0000.		
1.	0.	0.	00.	000.	000.	0000.	0000.		
0.	0.	00.	00.	000.	0000.	0000.	0000.		
0.	00.	00.	000.	000.	0000.	0000.			
0.	00.	00.	000.	0000.	0000.				
00.	00.	000.	000.	0000.	0000				
00.	000.	000.	0000.	0000.					
00.	000.	000.	0000.	0000.					
000.	000.	0000.	0000						
000.	0000.	0000.							

THE WESTING HOUSE SYSTEM.

WIRING TABLE FOR 50 VOLT LAMPS.

LOSS 1 VOLT=2 PER CENT.

Amperes or 16 C.P. Lamps.	Distance in Feet to Center of Distribution.							
	20'.	25'.	30'.	35'.	40'.	45'.	50'.	60'.
1.	16.	16.	16.	16.	16.	16.	16.	16.
1.5	16.	16.	16.	16.	16.	16.	16.	16.
2.	16.	16.	16.	16.	16.	16.	16.	16.
3.	16.	16.	16.	16.	16.	15.	15.	14.
4.	16.	16.	16.	15.	15.	14.	13.	13.
5.	16.	16.	15.	14.	13.	13.	13.	12.
6.	16.	15.	14.	13.	13.	12.	12.	11.
7.	15.	14.	13.	13.	12.	12.	11.	11.
8.	15.	14.	13.	12.	12.	11.	11.	10.
9.	14.	13.	12.	12.	11.	11.	10.	9.
10.	14.	13.	12.	11.	11.	10.	10.	9.
12.	13.	12.	11.	11.	10.	10.	9.	8.
14.	12.	11.	10.	10.	9.	9.	8.	7.
16.	12.	11.	10.	9.	9.	8.	8.	7.
18.	11.	10.	9.	8.	8.	7.	7.	6
20.	11.	10.	9.	8.	8.	7.	7.	6.
25.	10.	9.	8.	7.	7.	6.	6.	5.
30.	9.	8.	7.	7.	6.	5.	5.	4.
35.	8.	7.	7.	6.	5.	5.	4.	4.
40.	8.	7.	6.	5.	5.	4.	4.	3.
45.	7.	6.	5.	5	4.	4	3.	2.
50.	6.	6.	5.	4.	4.	3.	3.	2.
55.	6.	5.	5.	4.	3.	3.	2.	2.
60.	5.	5.	4.	4.	3.	3.	2.	1.
65.	5.	5.	4.	3.	3.	2.	2.	1.
70.	4.	4.	4.	3.	2.	2.	1.	1.
75.	4.	4.	3.	3.	2.	1.	1.	0.
80.	3.	3.	3.	2.	2.	1.	1.	0.
90.	3.	3.	2.	2.	1.	1	0.	00
100.	2.	2.	2.	1.	1.	0.	0.	00

Wire Sizes are Indicated Below in B. & S. Gauge.								
70'.	80'.	90'.	100'.	120'.	140'.	160'.	180'.	200'.
16.	16.	16.	16.	16.	15	14.	14.	13.
15.	15.	15.	14.	14.	13.	13.	12.	11.
15	15.	14.	13.	13.	12.	12.	11.	10
13.	13	12.	12.	11.	10.	10.	9.	9.
12	11	11.	10	10.	9.	8.	8.	7
11.	11	10.	10.	9.	8.	8.	7.	7
11.	10.	10.	9.	8	8.	7.	7.	6.
10.	9	9.	8.	8.	7.	6.	6.	5.
9.	9.	8.	8.	7.	6.	6	5.	5.
9.	8.	8.	7.	6.	6.	5.	5.	4.
8.	8	7.	7.	6.	5.	5.	4.	4.
8.	7.	7.	6.	5.	5.	4.	4.	3.
7.	6.	6.	5.	4.	4.	3.	3.	2.
6.	6.	5.	5.	4.	3.	3.	2.	2.
6.	5.	5.	4.	3..	3.	2.	2.	1.
5.	5.	4.	4.	3.	2.	2.	1.	1
4.	4.	3.	3.	2.	1.	1.	0.	0.
3.	3.	2.	2.	1.	0.	0.	0.	00.
3.	2.	2.	1.	1.	0.	00.	00.	000.
2.	2.	1.	1.	0.	00.	000.	000.	000.
2.	1.	1.	0.	00.	00.	000.	000.	0000.
1.	1.	0.	0.	00.	000.	000.	0000.	0000.
1.	0.	0.	00.	00.	000.	0000.	0000.	0000.
0.	0.	00.	00.	000.	000.	0000.	0000	
0.	0.	00.	00.	000.	0000.	0000		
0.	00.	00.	000.	000.	0000.	0000.		
00.	00.	000.	000.	0000.	0000.			
00.	00.	000.	000.	0000.	0000.			
00.	000.	000.	0000.	0000.				
000.	000.	0000.	0000.					

ST'D. LAMPS
10.cp. 0.7 a.
16. " 1. "
25. " 1.5 "
50. " 3 "
150. " 9 "

Table of Different Gauges, with their Diameters and Areas in Mils.

STANDARD.			AMERICAN.			BIRMINGHAM.		
No of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²
7-0	500	250000						
6-0	464	215296	4-0	4600	211600	4-0	454	206116
5-0	432	186824				3-0	425	180625
4-0	400	160000	3-0	4096	167805			
3-0	372	138384	2-0	3648	133079	2-0	380	144400
2-0	348	121104				0	340	115600
0	324	104976	0	3249	105592			
1	300	90000				1	300	90000
2	276	76176	1	2893	83694	2	284	80656
3	252	63504	2	2576	66373	3	259	67081
4	232	53824	3	2294	52634	4	238	56644
5	212	44944				5	220	48400
6	192	36864	4	2043	41742	6	203	41209
7	176	30976	5	1819	33.02	7	180	32400
8	160	25600	6	162	26244	8	165	27225
9	144	20736	7	1443	20822	9	148	21904
10	128	16384	8	1285	16512	10	134	17956

Table of Different Gauges, with their Diameters and Areas in Mils.

STANDARD.			AMERICAN.			BIRMINGHAM.		
No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²
11	116	13456	9	1144	13110	11	120	14400
12	104	10816	10	1019	10381	12	109	11881
13	092	8464	11	0907	8226	13	095	9025
14	080	6400	12	0808	6528	14	083	6889
15	072	5184	13	072	5184	15	072	5184
16	064	4096	14	0641	4110	16	065	4225
17	056	3136	15	0571	3260	17	058	3364
18	048	2304	16	0508	2581	18	049	2401
			17	0452	2044	19	042	1764
19	040	1600	18	0403	1624			
20	036	1296	19	0359	1253	20	035	1225
21	032	1024	20	032	1024	21	032	1024
22	028	784	21	0285	820	22	028	784
23	024	576	22	0253	626	23	025	625
24	022	484	23	0226	510	24	022	484
25	020	400	24	0201	404	25	020	400
26	018	324	25	0179	320	26	018	324

GLOSSARY OF ELECTRICAL TERMS.

ACCUMULATOR.—See battery and condenser.

AMMETER.—An instrument for measuring current strength.

AMPERE.—The unit of current strength. It is the flow of electricity produced by the pressure of one volt on a resistance of one ohm.

ARC.—The stream of hot gasses and particles of carbon visible between the carbons of an arc lamp.

ARMATURE.—That part of a dynamo in which the current is induced. It may be a stationary or moving part, but is generally the latter, and is composed of coils of wire which "cut" the lines of magnetic force produced by the fields. This "cutting" induces a current in the coils.

BATTERY.—One or more cells in which electricity is produced by chemical action. There are two elements of different substances and a liquid in every voltaic battery. A primary battery is one in which the "elements" are placed and used until they are worn out. In a secondary or storage battery or accumulator the "elements" are placed in the cell and first "formed" by the passage of a current of electricity through them. The cell is then said to be charged and may be used to supply electricity. The term battery is also used to designate a collection of Leyden jars in which static electricity is stored.

BRUSH.—A collection of metal sheets or wires which press against the commutator of a dynamo to collect the electricity, or of a motor to supply it. Carbon brushes are coming into use now, especially in railway work.

B. & S.—Brown and Sharp. The wire gauge used in America.

B. W. G.—Birmingham wire gauge. The English wire gauge.

CELL.—The jar in which the elements and liquid of a battery are placed. The term is used also for the jar and its contents.

C. G. S.—The abbreviation of centimetre, gramme, second, and used to designate the so-called absolute system of measurements.

CIRCUIT.—A system of conductors over which electricity passes.

COIL, CLOSED.—The coils of an armature are said to be closed when the end of one is connected to the beginning of the next at the commutator bar. An open coil armature is one in which each coil is independent of the others and has its own commutator bars.

COMMUTATOR.—That part of a dynamo on which the current from the armature is rectified before passing to the external circuit. The current in a given section of an armature alternates and must be made continuous on leaving it. This is done by the commutator, which consists of a series of insulated metal bars connected to the armature wires and so placed as to feed into different brushes as the current changes.

CONDENSER.—An apparatus for collecting and holding electricity. It consists of alternate layers of conducting sheets and insulating material, the conductors being very close together, and the adjacent ones being charged with the opposite kinds of electricity. Their proximity enables them to hold a larger amount of electricity than they could if alone. Condensers are sometimes called accumulators.

CONDUCTOR.—A substance which will allow the passage of electricity over it. All substances will do this, but some to so small an extent that they are called insulators.

COULOMB.—The unit of electric quantity. It is the amount of electricity which flows past a given point in one second on a circuit conveying one ampere.

CURRENT.—The flow of electricity in a conductor analogous to the flow of water in a pipe. A continuous current is one that does not change its direction, while an alternating current is one that periodically reverses.

CUT OUT.—An arrangement for interrupting a current or for shunting it around some part of a circuit.

DYNAMO.—A machine driven by power which furnishes electricity.

DYNAMOMETER.—An apparatus for measuring the power given out or consumed by a machine. An electro-dynamometer is an instrument for measuring a current by the mutual action of two coils through which it passes.

ELECTRODE.—A pole of a battery.

E. M. F.—An abbreviation for electro-motive force. This is the pressure which forces the electric current through a conductor.

ELECTRO-MAGNET.—A magnet produced by passing a current through a coil of wire around a soft iron core. The core is magnetized while the current flows, but loses its magnetism when the current stops. This form of magnet may be made much more powerful than a permanent magnet, and is therefore used in place of the latter in dynamos.

FARAD.—The unit of capacity. A condenser that will hold one coulomb at a pressure of one volt has a capacity of one farad.

FILAMENT.—In an incandescent lamp the thread of carbon which becomes luminous when the current is passed through it.

GALVANOMETER.—An instrument for detecting and measuring the electric current by the action of a coil of wire upon a magnetic needle.

INDUCTION.—A current is said to be induced in a conductor when it is caused by the conductor cutting lines of magnetic force. A fluctuating current in a conductor will tend to induce a fluctuating current in another running parallel to it. A static charge of electricity is induced in neighboring bodies by the presence of an electrified body. A magnet "induces" magnetism in neighboring magnetic bodies.

INDUCTION COIL.—An arrangement by which an alternating or fluctuating current in a coil of wire will induce an alternating current in a parallel coil.

INSULATOR.—The opposite of a conductor. A body which will not allow the passage of electricity except in such small quantities as to be negligable.

LINES OF FORCE.—Imaginary lines which radiate from a magnet and show by their direction the path which a free magnetic pole would take if left to itself. Conventionally the strength of a magnetic field is indicated by the number of these lines. Their form is shown by the well known experiment with the magnet and iron filings.

MAGNET.—A body possessing the property of attracting iron, steel and a few other metals.

MAGNETIC FIELD.—The space around a magnet in which its power of attraction is exhibited.

MULTIPLE or MULTIPLE ARC.—A method of connecting electric conductors by which a number of sources of electricity feed directly into or a number of receivers of electricity take it directly from the same mains.

NEGATIVE.—A conventional term to indicate the direction of flow of a current, or the state of electrification of a body. The negative or terminal of a dynamo is the one at which electricity enters it from the external circuit, while the negative terminal of a lamp or instrument is that connected towards the negative terminal of a dynamo. It is designated by —

OHM.—The unit of electrical resistance.

OHMS LAW.—States that the current in any circuit is equal to the E. M. F. acting on it divided by its resistance.

PERMANENT MAGNET.—A piece of hardened steel which retains its magnetism after the magnetizing influence is removed.

PARALLEL.—See Multiple.

POLE.—Those parts of a magnet which show the strongest magnetic force. In a bar magnet this is generally a short distance from the ends. The pole of a dynamo or battery is one of its terminals.

POSITIVE.—A conventional term to show the direction of a current. In a dynamo or battery it is the terminal at which the electricity leaves it. It is designated by **X**.

POTENTIAL.—Power to do work. It is commonly used as synonymous with electro-motive force in speaking of dynamos or batteries.

RESISTANCE.—The opposition offered by a body to the passage of electricity through it.

RHEOSTAT.—An apparatus for throwing a variable resistance into a circuit at will.

SERIES.—Two or more conductors are said to be in series when they are so connected that the same current that passes through one passes through the other.

SHORT CIRCUIT.—An indefinite term used generally in the case of dynamos and batteries for a resistance between the terminals lower than the machine or battery is calculated to stand or run on in practice. With lamps the term is used for a low resistance between the terminals, which deprives it of most of the current.

SHUNT.—A shunt is a conductor connected around another in such a way that it deprives the first of a part of the current.

SOLENOID.—A hollow coil of wire.

TERMINAL.—The point at which the electricity enters or leaves an electrical apparatus.

VOLT.—The unit of electro-motive force or pressure analogous to the head of water in hydraulics.

VOLTMETER.—An instrument for measuring the voltage or pressure on a circuit.

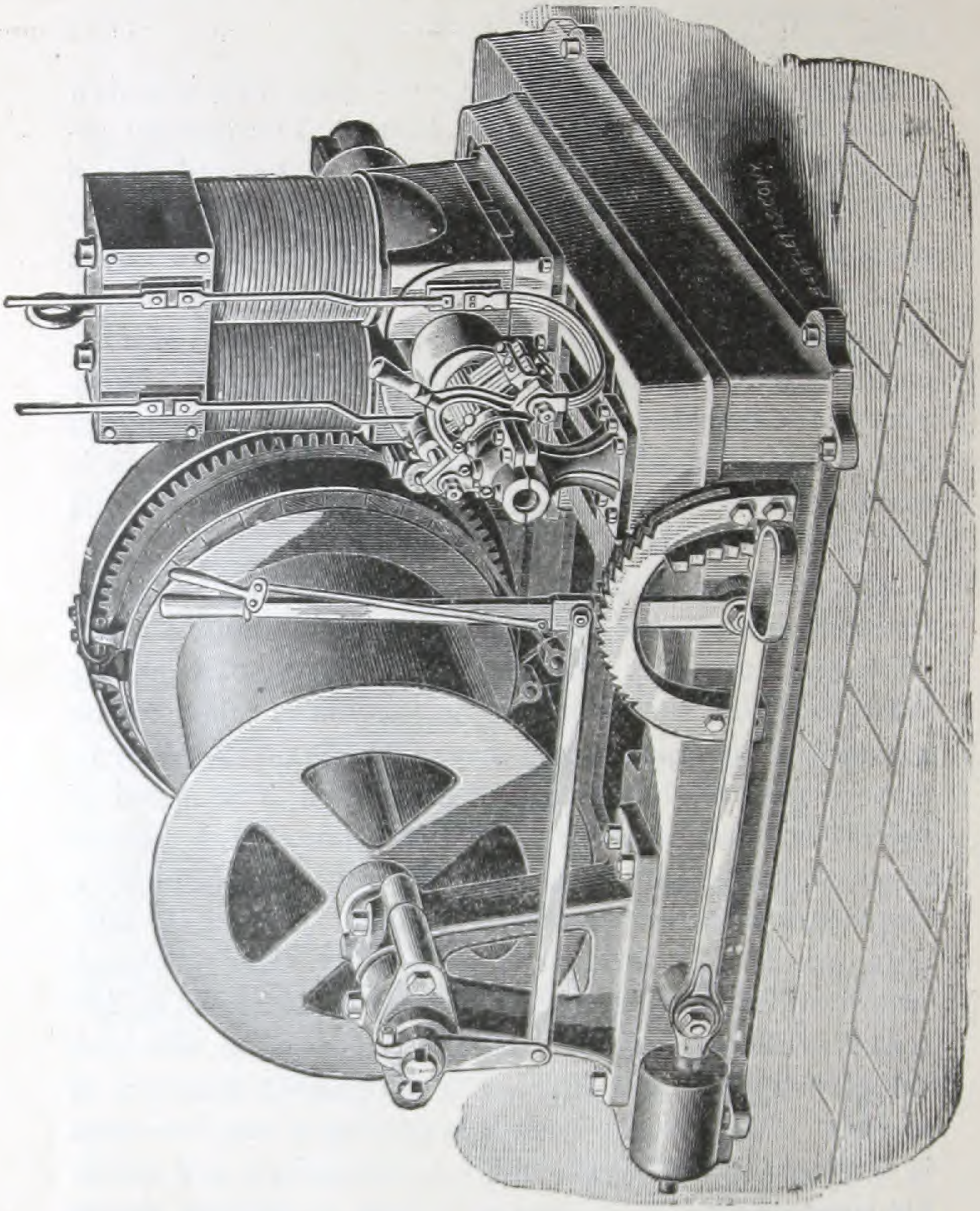
WATT.—The unit of work. The watts developed in a circuit are equal to the current multiplied by the E. M. F. 746 watts equal one horse power.

WATTMETER.—An instrument for measuring the electrical energy in a circuit.

APPENDIX.

Edison Electric Mining Hoist.—On page 122, is a view of the Edison Electric Mining Hoist. The general arrangement of the two different parts can be understood very easily from the view given. Direct gearing between the armature and drum is used, and all gears are boxed in iron cases to protect them from dust or stray stones. At the same time the cases can be quickly removed if occasion should require to reach the working parts. Every part of the machine is designed to give the greatest power with the least weight, and by this means the machine is made quite light and can be easily transported from one part of the mine premises to another.

The qualities of durability, compactness, ease of operation and minimum of wear, so essential in mining work, have been carefully attended to in this machine. The view presented shows that no extra room is taken up by any part of the apparatus. Everything is arranged to fit closely upon the base frame of the hoist. The speed of the motor is controlled by a switch at one side, by means of which the motor can be made to vary its speed by a single movement of the switch handle. Turning the handle to one division will make the motor run slowly, through two divisions, faster, and full number of divisions at full speed, while turning the handle in the opposite direction will give similar rates of speed with opposite direction of motion. This electric hoist is supplying a long felt want in mining and mill work, where a convenient and portable hoist which can be operated from a lighting circuit already installed, has been needed.

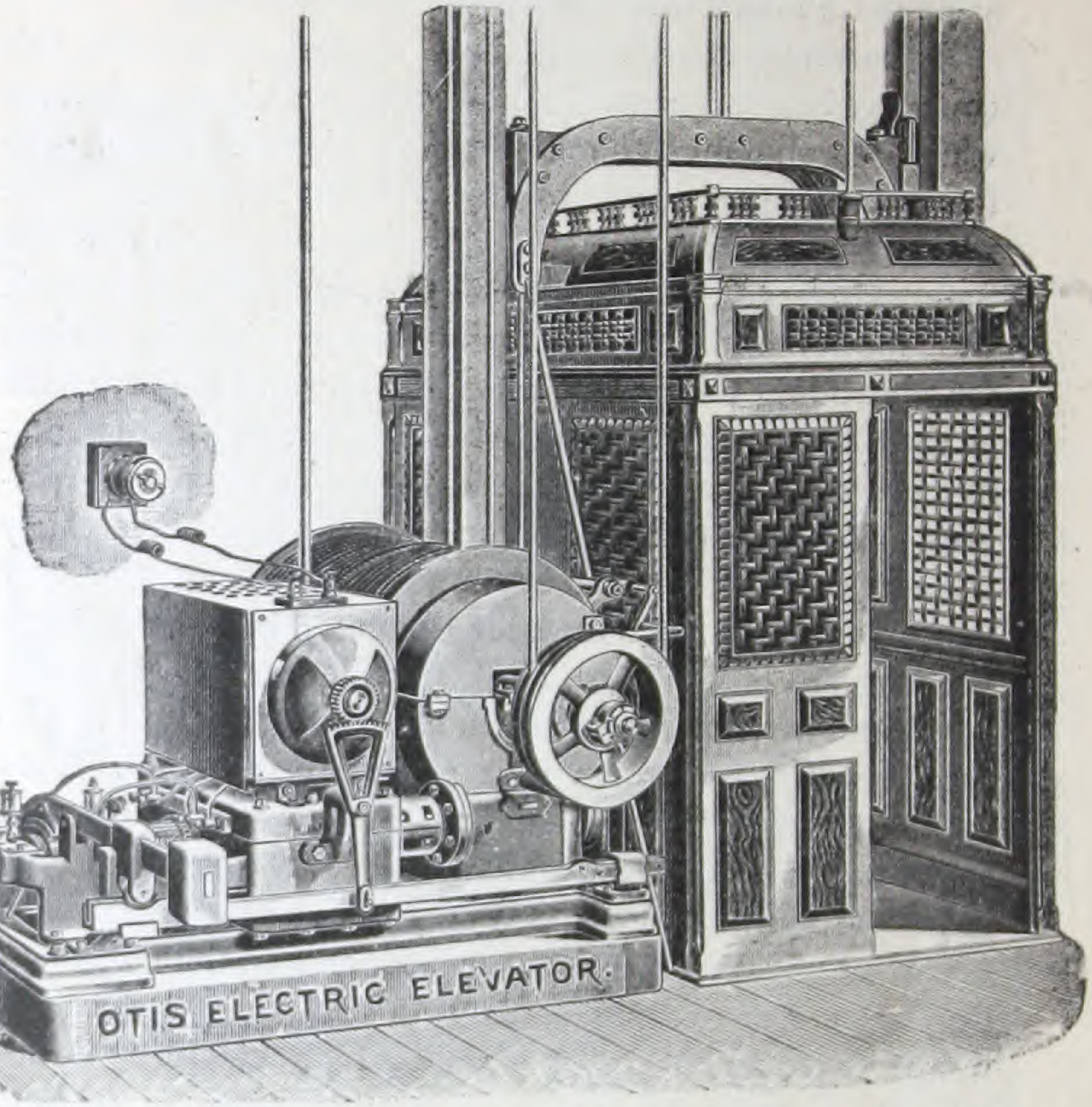


EDISON ELECTRIC MINING HOIST.

The Otis Electric Elevator.—Elevator machinery, as a rule, meets with the roughest manipulation while in use. No other apparatus operated by electric power is exposed to such strain—not even in street railway service, where, at least, the same operator is constantly in charge and a systematic inspection considered indispensable.

By carefully considering these special conditions, this company has succeeded in perfecting an electric elevator which is well suited to many places where it has heretofore been impracticable to use such an apparatus. The winding-machinery and safety appliances (including the Safety Governor, the Gravity Wedge Safety, the Automatic Stop-motion and the Slack-cable Stop; also the devices for controlling the movement of the elevator car) are such as they have been constantly building for the past twenty-five years; consequently there are no experimental features. To give motion to the elevator machinery, they connect therewith, and make a part of the same, the very ingeniously constructed motor (invented by Mr. Rudolph Eickemeyer, of Yonkers, N. Y.,) which possesses many novel and meritorious features, especially adapted to elevator service, for which it is expressly designed. This motor, when so combined with the elevator, stops and starts with a gradual movement, and consumes power only in proportion to its load, and only while the elevator is in use, thus effecting the greatest economy in the consumption of power. It possesses in a high degree the best points of motor construction, and a high efficiency is obtained. Simple and accessible in all its parts, of the best material to meet electrical and mechanical requirements, it is also protected by its unique construction, which makes the motor completely iron-clad, without adding any unnecessary weight. It has, further, the special advantage

of a powerful field and the shortest possible magnetic circuit, which entirely prevents "sparking" at the commutator, and affords perfect self-regulation. It may also be added that, although it possesses a very strong magnetic field, yet there is no external magnetism in the



machine. The motor is so coupled to the elevator-gear that it starts and stops with the winding-machinery, the whole being under perfect control of the operator in the car, thus forming a self-contained apparatus, free from jerky and irregular running of detached gearing, as when operated by belts.

The Isle of Shoals Cable.—The Isle of Shoals situated a few miles off the New Hampshire coast, is one of the most charming marine resorts New England can boast of, and that is saying a great deal.

This group of islands has won a world-wide reputation for its quietude and invigorating air, and for years past there has been a constantly increasing number of visitors there from many parts of the United States. So important a summer resort have the islands now become that it has been deemed advisable to provide cable facilities, for transcient patrons as well as residents, with the outer world, thereby enabling gentlemen to maintain communication with their home friends and business associates, and when necessary transact business which might be urgent. With this end in view, a number of capitalists interested in the continued prosperity of the Isle of Shoals organized the Gardner Cable Co., for the purpose of laying a submarine cable from Appledore Island to the mainland. In April last the project had so far advanced that a contract was made with Mr. C. S. Knowles, of Boston, representing the Safety Insulated and Wire Cable Co. of New York, to manufacture such a cable as was necessary. The cable itself is $1\frac{1}{4}$ inches in diameter, containing two wires, protected by insulation, and armored with 15 strands of No. 8 galvanized iron wire. The total weight was about 36 tons.

The cable on an immense truck, as shown, was shipped from New York on a barge, which was towed to its destination by the tug R. C. Veit. On the morning of the day set nearly every soul on the islands turned out to watch the work of laying the cable.

Notwithstanding that a northeast gale had left a strong surf rolling, the work was accomplished in a few hours,

APPLEDORE ISLAND.

SHIPPING THE CABLE.

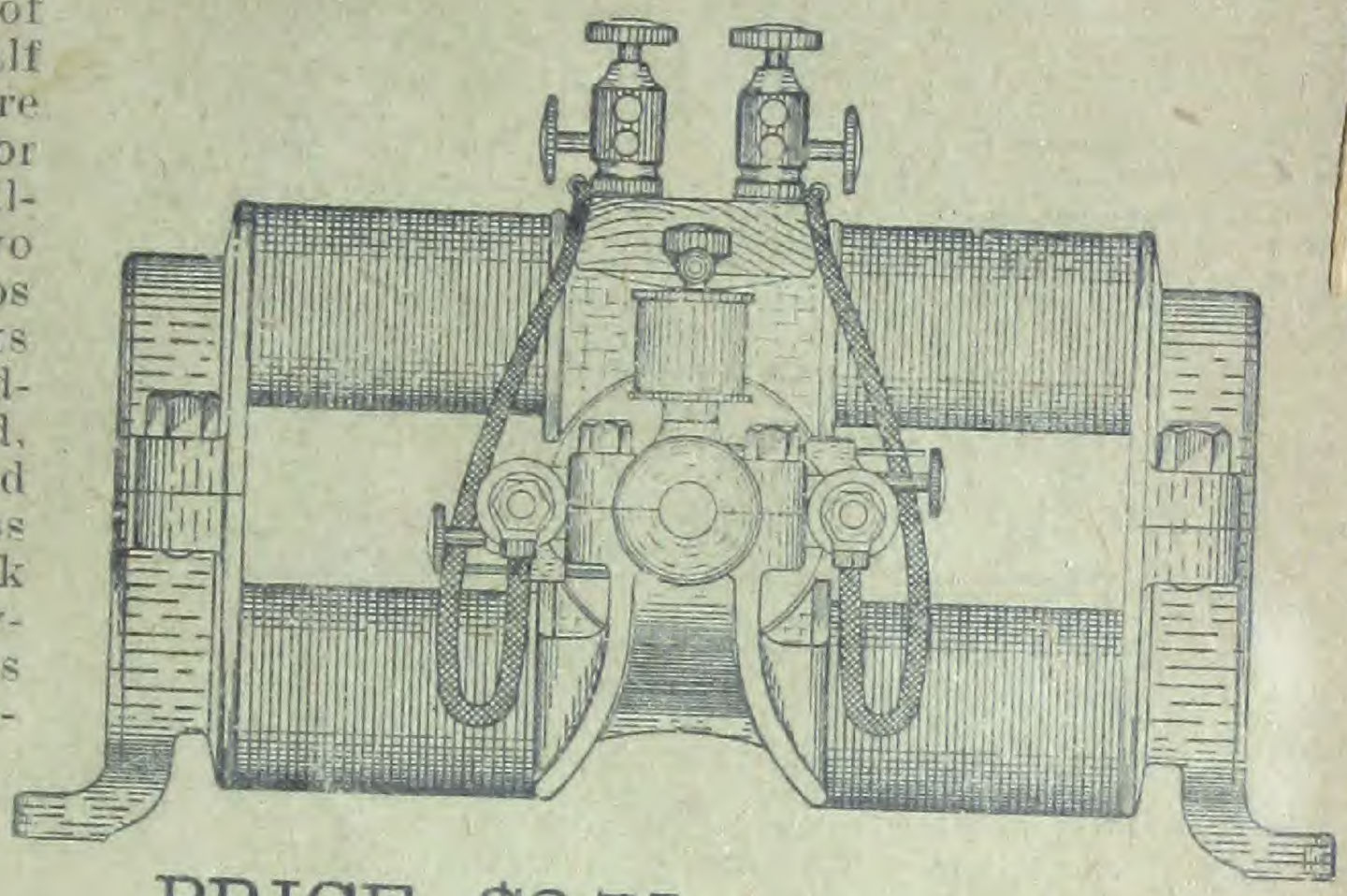
telegraphic communication with the outer world being promptly established. The work of paying out the cable went on at a rate of nearly three miles an hour, the end on the mainland being first secured, the tug then steering towards the islands. When it was proved that there would be some difficulty and delay in landing the mainland end of the cable, ropes were made fast to it, and about every person present assisted in hauling on the ropes. The cable lands near the point shown in the accompanying cut, which gives an accurate view of Appledore Island with hotel and cottages. The Postal Telegraph Cable steamer, Captain West, rendered valuable assistance. As soon as telegraph connection could be made with the Western Union Company's line, the following message was dispatched from Appledore Island to Mr. Oscar Leighton, one of the proprietors of the hotel and a director of the cable company: "You are at last connected by wire with the United States. Praise God from whom all blessings flow."

The cable itself was a magnificent piece of work, being 36,000 feet in length. When loaded on a heavy truck for transportation from the works to the wharf where it was transferred to a barge, in New York, the whole weighed 53 tons, and to haul this mass through the streets of the metropolis no less than thirty horses were harnessed to the truck. It is said to have been the heaviest load that ever was hauled through New York City, and naturally excited much attention. The cable is now in regular service, giving great satisfaction, and its value as a means of communication with the mainland has already impressed itself on the minds of the authorities, so that there is a probability of a life-saving signal station being established on the islands.

This Two-Light Dynamo

Is designed especially for experimental work and for use in schools and colleges. Gives 35 volts and $6\frac{1}{2}$ amperes, either direct current or alternator, will run two 16 candle-power lamps, or one small arc lamp. Complete set of castings for this dynamo consisting of

One upper half of field; one lower half of field; one armature core; two caps for bearings, and one pulley—cast iron; two bearings; two oil cups and two covers; parts for four brush holders; one two-ended, and one four-ended yoke, these are brass or gun metal; book giving working drawings and directions for making the dynamo.



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